Production Line Equipment

For

Lightweight Intelligent Agricultural Machinery

Summary

This set of documents is used for the manufacturing of agricultural machinery, covering the processing of parts and the assembly of the entire machine.

Table of Contents

1. Lightweight Intelligent Agricultural Machinery Structure

Reference images: Agricultural Plant Protection Machinery

Table: Components of Agricultural Plant Protection Machinery and Their Corresponding Functions

Component	Sub-Component	Function Description	Notes
Wing	Spar	Bears the shear force and bending moment of the wing, providing structural strength.	The strongest longitudinal component of the wing.
	Stringers	Provide longitudinal support and enhance the rigidity of the wing.	-
	Ribs	Provide transverse support, maintain the wing's shape, and transfer loads.	-
	Skin	Covers the framework to form the aerodynamic shape of the wing and withstand aerodynamic loads.	-
	Flaps	Increase lift and drag, mainly used during takeoff and landing.	May be electrically or mechanically driven.
	Ailerons	Control the drone's roll motion.	Located at the wingtips, they change the airflow

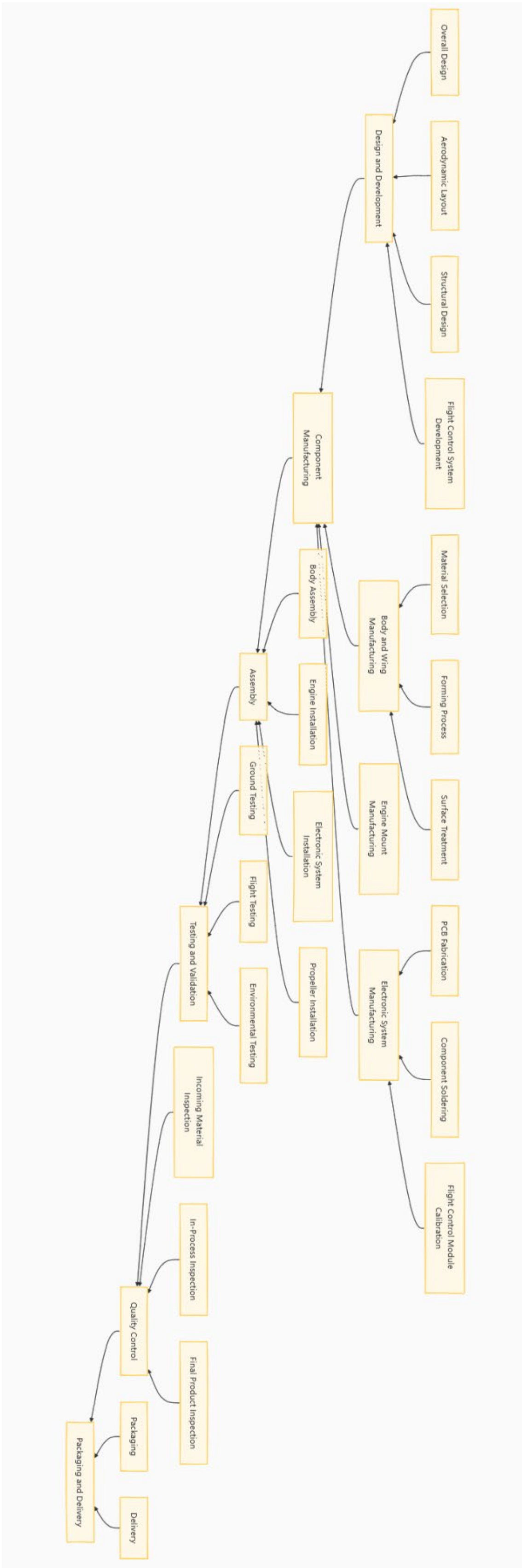
			direction to achieve roll control.
Fuselage	Longitudinal Framework (Spar, Stringers)	Bear the longitudinal loads of the fuselage and provide structural strength.	-
	Transverse Framework (Bulkheads)	Provide transverse support and divide the fuselage into sections.	Includes regular and reinforced bulkheads.
	Skin	Covers the framework to form the aerodynamic shape of the fuselage and protect internal equipment.	-
	Payload Bay	Used to carry equipment, fuel, or other payloads.	Position and size are determined by the drone's purpose.
	Internal Fuel Tank	Stores fuel and supplies it to the engine.	Tank capacity is designed based on the drone's endurance requirements.
Tail	Horizontal Stabilizer	Includes the horizontal stabilizer and elevator, used to control the drone's pitch.	The elevator is adjustable to change the airflow direction for pitch control.
	Vertical Stabilizer	Includes the vertical stabilizer and rudder, used to control the drone's yaw.	The rudder is adjustable to change the airflow direction for yaw control.
Landing Gear	Struts	Bear ground loads and support the wheels.	-
	Shock Absorbers	Absorb impact energy during landing and taxiing, protecting the fuselage structure.	May be oleo-pneumatic or spring-based shock absorbers.

	Wheels	Used for ground movement and takeoff/landing.	May be single or multi-wheel design.
	Retraction Mechanism	Controls the retraction and extension of the landing gear to reduce drag during flight.	High-performance drones often feature retractable landing gear.
Power Plant	Gasoline Engine	Converts chemical energy into mechanical energy to drive the propeller.	Engine size is selected based on power requirements.
	Generator	Converts the engine's mechanical energy into electrical energy to power onboard equipment.	Generator power and output voltage are designed based on drone requirements.
	DC Power Module	Converts the generator's AC power to DC power for the flight control system and electronic equipment.	Common output voltages are 24V or 28V, with power ratings up to 300W or more.
	Propeller	Generates thrust by rotating, propelling the drone forward.	May be fixed-pitch or variable-pitch propellers.
	Fuel System	Includes fuel tanks, fuel lines, and fuel pumps to store and deliver fuel.	Tank location and capacity are determined by drone design.
	Ignition System	Includes spark plugs and ignition coils to ignite the fuel.	-
	Intake System	Includes air filters and intake pipes to supply clean air to the engine.	-
	Exhaust System	Includes exhaust pipes and mufflers to expel combustion gases and reduce noise.	-

Control System	Flight Control Computer	Processes sensor data and controls the drone's flight attitude and trajectory.	The core component for autonomous flight and remote control functions.
	Sensors (IMU, GPS, etc.)	Provide information on the drone's attitude, position, and velocity.	-
	Servo Motors	Drive the control surfaces (ailerons, elevator, rudder) and flaps.	-
	Remote Control Receiver	Receives remote control commands and transmits them to the flight control computer.	-
Electrical System	Battery	Powers the flight control system, sensors, and other electronic devices.	-
	Power Management Module	Distributes and manages electrical power, protecting the circuit.	-
	Electronic Speed Controller (ESC)	Controls engine speed (for electric drones) or servo motor movement.	Gasoline drones may not have an ESC but have similar functional components.
Other Components	Antenna	Used for data transmission and communication.	Includes remote control signal antennas and data link antennas.
	Lighting System	Provides lighting and signaling functions for night flights.	May include navigation lights, landing lights, etc.
	Payload Devices (Optional)	Can carry cameras, radars, sensors, or other equipment based on mission requirements.	Position and method of attachment are determined by drone design.

2. Overview of the Entire Manufacturing Process

2.1. Process Flow Diagram



I. Design and Development Phase

1.1 Overall Design

- Objective: Clarify the functionality, performance indicators, and application scenarios of the drone.
- Content:
  - Determine the type of drone (Pesticide spraying).
  - Design basic parameters, including size, weight, payload capacity, range, and endurance.
  - Develop an overall design plan, covering the power system, flight control system, and structural layout.
- Tools: CAD software for preliminary modeling.

1.2 Aerodynamic Layout Design

- Objective: Optimize the aerodynamic performance of the drone to enhance lift and reduce drag.
- Content:
  - Design wing shapes, airfoils, aspect ratios, and sweep angles.
  - Select appropriate tail configurations (e.g., T-tail, V-tail).
  - Use CFD (Computational Fluid Dynamics) software for aerodynamic simulations to validate the design.
- Tools: ANSYS Fluent, XFOIL, etc.

1.3 Structural Design

- Objective: Ensure the strength and lightweight nature of the drone’s structure.
- Content:
  - Select suitable materials (e.g., carbon fiber composites, aluminum alloys).

    - Use CAD software for detailed structural design, including dimensions and structures of the fuselage, wings, and tail.
    - Perform finite element analysis (FEA) to verify structural strength.
- Tools: ABAQUS, ANSYS, etc.

1.4 Flight Control System Development

- Objective: Develop a reliable flight control system to ensure stable drone flight.
- Content:
    - Write flight control algorithms, covering attitude control, heading control, and altitude control.
    - Integrate sensors (e.g., gyroscopes, accelerometers, barometers).
    - Tune PID parameters to optimize flight performance.
    - Conduct ground and flight tests to verify the reliability of the flight control system.
- Tools: Arduino, STM32, ARM Linux development platforms.

II. Component Manufacturing Phase

2.1 Body and Wing Manufacturing

- Objective: Produce high-quality body and wing components.
- Content:
    - Material Selection: Choose materials such as carbon fiber composites, glass fiber composites, or aluminum alloys.
    - Forming Process: Use processes like autoclave curing, press molding, or hand lay-up and curing.
    - Surface Treatment: Perform sanding and painting on the formed components to enhance durability and appearance.

- Tools: Autoclave, molds, painting equipment.

2.2 Engine Mount Manufacturing

- Objective: Manufacture robust and well-fitted engine mounts.
- Content:
  - Select aluminum or titanium alloy materials.
  - Use CNC machining centers for high-precision processing.
  - Inspect the dimensional accuracy and surface quality of the mounts.
- Tools: CNC machining equipment, CMM (Coordinate Measuring Machine).

2.3 Electronic System Manufacturing

- Objective: Produce reliable electronic systems, including flight control modules, ESCs, and motors.
- Content:
  - PCB Fabrication: Use processes like etching, drilling, and plating to manufacture multi-layer circuit boards.
  - Component Soldering: Use SMT (Surface-Mount Technology) machines for high-precision soldering of resistors, capacitors, and chips.
  - Flight Control Module Calibration: Calibrate sensors such as gyroscopes and accelerometers to ensure measurement accuracy.
- Tools: PCB etching equipment, SMT machines, calibration instruments.

III. Assembly Phase

3.1 Body Assembly

- Objective: Assemble the fuselage, wings, and tail into a complete drone structure.
- Content:

    - Use bolts and adhesives to connect the components.
    - Inspect the overall structural strength and dimensional accuracy after assembly.
    - Ensure tight and secure connections between components.
- Tools: Torque wrenches, adhesive application equipment.

3.2 Engine Installation

- Objective: Install the gasoline engine and ensure its proper operation.
- Content:
    - Secure the engine to the engine mount.
    - Connect the fuel system, ignition system, and cooling system.
    - Inspect the installation accuracy and operational status of the engine.
- Tools: Engine test stands, fuel pumps.

3.3 Electronic System Installation

- Objective: Install and commission the drone's electronic systems.
- Content:
    - Install electronic devices such as flight control modules, ESCs, and motors on the drone.
    - Connect cables to ensure the normal operation of the electrical system.
    - Tune the flight control system and calibrate sensors and control parameters.
- Tools: Multimeters, oscilloscopes.

3.4 Propeller Installation

- Objective: Install the propeller and ensure it matches the engine.
- Content:
    - Select an appropriate propeller based on the engine's power and RPM.

    - Secure the propeller to the engine shaft and ensure it is tightly installed.
    - Inspect the balance and installation accuracy of the propeller.
- Tools: Propeller balancers.

IV. Testing and Validation Phase

4.1 Ground Testing

- Objective: Conduct comprehensive inspections of the drone in a ground environment.
- Content:
    - Inspect the connections of all components for tightness.
    - Test the functionality of the electronic system, including flight control modules, sensors, and communication systems.
    - Check the fuel system for leaks to ensure sealing.
    - Perform engine start-up tests to check its operational status.
- Tools: Multimeters, pressure testing equipment.

4.2 Flight Testing

- Objective: Validate the drone’s flight performance.
- Content:
    - Conduct the first test flight to check basic performance, including takeoff, hovering, and flight attitude.
    - Perform flight tests along predefined routes to validate navigation and autonomous flight functions.
    - Test the drone’s maximum speed, range, and endurance.
    - Collect flight data to analyze performance and optimize flight control parameters.

- Tools: GPS positioning devices, flight data recorders.

4.3 Environmental Testing

- Objective: Test the drone’s reliability under different environmental conditions.
- Content:
  - Conduct vibration tests on a vibration test bench to simulate in-flight vibrations.
  - Perform temperature tests in high/low-temperature chambers to verify performance in extreme conditions.
  - Test waterproofing and dustproofing capabilities to ensure reliability in harsh environments.
- Tools: Vibration test benches, high/low-temperature chambers.

V. Quality Control Phase

5.1 Incoming Material Inspection

- Objective: Ensure the quality of raw materials and components meets design requirements.
- Content:
  - Use XRF spectrometers to analyze material composition.
  - Inspect the dimensional accuracy and appearance quality of components.
  - Conduct sampling inspections on key components to ensure they meet performance standards.
- Tools: XRF spectrometers, CMM (Coordinate Measuring Machines).

5.2 In-Process Inspection

- Objective: Monitor the quality during the production process.
- Content:

    - Implement first-article inspection to ensure production stability.
    - Maintain process records at each production stage for traceability.
    - Regularly inspect the operational status of production equipment to ensure accuracy.
- Tools: Inspection record sheets, production equipment monitoring systems.

5.3 Final Product Inspection

- Objective: Ensure the quality of the finished drone meets the factory standards.
- Content:
    - Conduct 72-hour aging tests on the finished drone to check long-term reliability.
    - Record flight parameters to analyze whether performance meets design requirements.
    - Inspect the appearance quality to ensure there are no scratches or defects.
- Tools: Flight data recorders, appearance inspection equipment.

VI. Packaging and Delivery Phase

6.1 Packaging

- Objective: Ensure the drone is protected during transportation.
- Content:
    - Use moisture-proof and shock-absorbent materials for packaging.
    - Add fixing devices inside the packaging box to prevent movement during transport.
    - Label the packaging box with dimensions, weight, and transportation precautions.
- Tools: Moisture-proof bags, foam materials, packaging boxes.

6.2 Delivery

- Objective: Deliver the finished drone to customers or store it in inventory.

- Content:
  - Verify order information to ensure the delivered product meets customer requirements.
  - Provide user manuals, warranty cards, and certificates of conformity.
  - Arrange logistics for timely delivery to customers.
- Tools: Logistics transportation equipment, user manuals.

3. Materials, Processes, and Machining Equipment for Parts

3.1.List of Component Materials and Processing Equipment (Please ignore if components are purchased externally)

Component	Sub-Component	Material or Specifications	Manufacturing Equipment
Wing	Spar	Aluminum alloy (e.g., 7075-T6) or carbon fiber composite, high strength and lightweight.	CNC milling machine, composite material forming equipment
	Stringers	Aluminum alloy or carbon fiber composite, providing longitudinal support.	CNC milling machine, composite material forming equipment
	Ribs	Aluminum alloy or glass fiber-reinforced plastic (GFRP), maintaining wing shape and load transfer.	CNC milling machine, injection molding equipment
	Skin	Glass fiber-reinforced plastic (GFRP) or carbon fiber composite, good aerodynamic shape and weather resistance.	Autoclave, vacuum bagging equipment
	Flaps	Aluminum frame with composite skin, electrically or mechanically driven.	CNC milling machine, composite material forming equipment
	Ailerons	Aluminum frame with composite skin, controlled by servos.	CNC milling machine, composite material forming equipment
Fuselage	Longitudinal Framework (Spar, Stringers)	Aluminum alloy (e.g., 6061-T6) or carbon fiber composite, providing high strength and lightweight.	CNC milling machine, composite material forming equipment

	Transverse Framework (Bulkheads)	Aluminum alloy or carbon fiber composite, dividing the fuselage into sections.	CNC milling machine, composite material forming equipment
	Skin	Glass fiber-reinforced plastic (GFRP) or carbon fiber composite, protecting internal equipment.	Autoclave, vacuum bagging equipment
	Payload Bay	Designed based on mission requirements, typically using aluminum alloy or composite materials.	CNC milling machine, composite material forming equipment
	Internal Fuel Tank	High-density polyethylene (HDPE) or aluminum alloy, capacity designed based on endurance requirements.	Injection molding equipment, CNC milling machine
Tail	Horizontal Stabilizer	Aluminum frame with composite skin, elevator is adjustable.	CNC milling machine, composite material forming equipment
	Vertical Stabilizer	Aluminum frame with composite skin, rudder is adjustable.	CNC milling machine, composite material forming equipment
Landing Gear	Struts	Aluminum alloy or high-strength steel, bearing ground loads.	CNC lathe, welding equipment
	Shock Absorbers	Oleo-pneumatic or spring-based, absorbing impact energy during landing and taxiing.	Hydraulic press, spring forming equipment
	Wheels	Aluminum alloy hubs with rubber tires, suitable for various ground conditions.	CNC lathe, tire molding equipment

	Retraction Mechanism	Electric or hydraulic-driven, for retracting and extending the landing gear.	CNC milling machine, hydraulic equipment
Power Plant	Gasoline Engine	Four-stroke gasoline engine, power range 5~30kW, displacement selected based on requirements.	Engine assembly line, CNC machining center
	Generator	AC generator, power 1000~3000W, output voltage 28V AC.	Generator assembly equipment, winding equipment
	DC Power Module	Converts 28V AC to 24V DC, power >300W, efficiency ≥90%.	Electronic soldering equipment, power supply testing equipment
	Propeller	Glass fiber or carbon fiber composite, diameter 0.8~2 meters, fixed-pitch or variable-pitch.	CNC milling machine, composite material forming equipment
	Fuel System	High-density polyethylene (HDPE) fuel tank, fuel lines made of oil-resistant rubber.	Injection molding equipment, CNC milling machine
	Ignition System	High-energy electronic ignition system, spark plugs made of nickel alloy.	Ignition system testing equipment, electronic soldering equipment
	Intake System	Air filter made of high-performance polymer, intake pipes of aluminum alloy or composite materials.	Injection molding equipment, CNC milling machine
	Exhaust System	Stainless steel exhaust pipes, mufflers made of porous sound-absorbing materials.	CNC milling machine, welding equipment

Control System	Flight Control Computer	High-performance embedded processor, supporting multiple sensor interfaces.	Electronic soldering equipment, chip programming equipment
	Sensors (IMU, GPS, etc.)	MEMS Inertial Measurement Unit (IMU), accuracy ±0.1°; GPS module, positioning accuracy <1 meter.	Sensor calibration equipment, electronic soldering equipment
	Servo Motors	High torque density, fast response, operating voltage 24V.	Servo motor assembly equipment, motor test bench
	Remote Control Receiver	2.4GHz frequency band, supporting multi-channel remote control signals.	Electronic soldering equipment, signal testing equipment
Electrical System	Battery	Lithium polymer battery, voltage 11.1V, capacity >10000mAh.	Battery packaging equipment, battery testing equipment
	Power Management Module	Distributes and manages electrical power, protects the circuit, supports multiple power inputs.	Electronic soldering equipment, power supply testing equipment
	Electronic Speed Controller (ESC)	Controls engine speed (for electric drones) or servo motor movement.	Electronic soldering equipment, motor test equipment
Other Components	Antenna	High-gain antenna, operating frequency band 1.2GHz~5.8GHz.	Antenna testing equipment, electronic soldering equipment
	Lighting System	LED navigation lights, landing lights, operating voltage 24V.	Electronic soldering equipment, lighting fixture testing equipment

	Payload Devices (Optional)	Can carry cameras, radars, sensors, or other equipment based on mission requirements.	CNC milling machine, composite material forming equipment

3.2. Detailed description of the components, materials, specifications, manufacturing equipment, and processes for a gasoline-powered fixed-wing drone

3.2.1. Wing

3.2.1.1 Spar

- Material or Specifications: Made from aluminum alloy (e.g., 7075-T6) or carbon fiber composite. Aluminum alloy offers high strength and good machinability, while carbon fiber provides a higher strength-to-weight ratio.
- Manufacturing Equipment: CNC milling machines for aluminum alloy processing; composite material forming equipment for carbon fiber.
- Process: Aluminum alloy is processed through mechanical machining and surface treatment; carbon fiber is formed through mold shaping, curing, and finishing.

3.2.1.2 Stringers

- Material or Specifications: Aluminum alloy or carbon fiber composite, providing longitudinal support.
- Manufacturing Equipment: CNC milling machines for cutting and forming; composite material forming equipment for pre-preg layup and curing.
- Process: Aluminum alloy is cut and welded; carbon fiber is processed through pre-preg layup and hot-press curing.

3.2.1.3 Ribs

- Material or Specifications: Aluminum alloy or glass fiber-reinforced plastic (GFRP), maintaining the wing’s shape and load transfer.
- Manufacturing Equipment: CNC milling machines for aluminum alloy processing; injection

molding equipment for GFRP.

- Process: Aluminum alloy is cast and machined; GFRP is formed through injection molding and surface treatment.

3.2.1.4 Skin

- Material or Specifications: Glass fiber-reinforced plastic (GFRP) or carbon fiber composite, with good aerodynamic shape and weather resistance.
- Manufacturing Equipment: Autoclave for carbon fiber curing; vacuum bagging equipment for GFRP forming.
- Process: GFRP is formed through hand layup and vacuum curing; carbon fiber is processed through pre-preg forming and hot-press curing.

3.2.1.5 Flaps

- Material or Specifications: Aluminum alloy frame with composite skin, electrically or mechanically driven.
- Manufacturing Equipment: CNC milling machines for aluminum alloy frame processing; composite material forming equipment for skin forming.
- Process: Aluminum alloy is welded and machined; composite skin is bonded and assembled.

3.2.1.6 Ailerons

- Material or Specifications: Aluminum alloy frame with composite skin, controlled by servos.
- Manufacturing Equipment: CNC milling machines for aluminum alloy frame processing; composite material forming equipment for skin forming.
- Process: Aluminum alloy is welded and machined; composite skin is bonded and assembled.

3.2.2. Fuselage

3.2.2.1 Longitudinal Framework (Spar, Stringers)

- Material or Specifications: Aluminum alloy (e.g., 6061-T6) or carbon fiber composite, providing high strength and lightweight.
- Manufacturing Equipment: CNC milling machines for aluminum alloy processing; composite material forming equipment for carbon fiber.
- Process: Aluminum alloy is processed through mechanical machining and welding; carbon fiber is formed through mold shaping and curing.

3.2.2.2 Transverse Framework (Bulkheads)

- Material or Specifications: Aluminum alloy or carbon fiber composite, dividing the fuselage structure.
- Manufacturing Equipment: CNC milling machines for cutting and forming; composite material forming equipment for pre-preg layup and curing.
- Process: Aluminum alloy is cut and welded; carbon fiber is processed through pre-preg layup and hot-press curing.

3.2.2.3 Skin

- Material or Specifications: Glass fiber-reinforced plastic (GFRP) or carbon fiber composite, protecting internal equipment.
- Manufacturing Equipment: Autoclave for carbon fiber curing; vacuum bagging equipment for GFRP forming.
- Process: GFRP is formed through hand layup and vacuum curing; carbon fiber is processed through pre-preg forming and hot-press curing.

3.2.2.4 Payload Bay

- Material or Specifications: Designed based on mission requirements, typically using aluminum alloy or composite material structures.
- Manufacturing Equipment: CNC milling machines for aluminum alloy processing; composite material forming equipment for forming.

- Process: Aluminum alloy is processed through mechanical machining and welding; composite material is formed through mold shaping and curing.

3.2.2.5 Internal Fuel Tank

- Material or Specifications: High-density polyethylene (HDPE) or aluminum alloy, with capacity designed based on endurance requirements.
- Manufacturing Equipment: Injection molding equipment for HDPE tanks; CNC milling machines for aluminum alloy tanks.
- Process: HDPE is formed through injection molding; aluminum alloy is processed through welding and sealing.

3.2.3. Tail

3.2.3.1 Horizontal Stabilizer

- Material or Specifications: Aluminum alloy frame with composite skin, adjustable elevator.
- Manufacturing Equipment: CNC milling machines for aluminum alloy frame processing; composite material forming equipment for skin forming.
- Process: Aluminum alloy is welded and machined; composite skin is bonded and assembled.

3.2.3.2 Vertical Stabilizer

- Material or Specifications: Aluminum alloy frame with composite skin, adjustable rudder.
- Manufacturing Equipment: CNC milling machines for aluminum alloy frame processing; composite material forming equipment for skin forming.
- Process: Aluminum alloy is welded and machined; composite skin is bonded and assembled.

3.2.4. Landing Gear

3.2.4.1 Struts

- Material or Specifications: Aluminum alloy or high-strength steel, bearing ground loads.
- Manufacturing Equipment: CNC lathes for aluminum alloy processing; welding equipment for steel.
- Process: Aluminum alloy is forged and machined; steel is processed through welding and heat treatment.

3.2.4.2 Shock Absorbers

- Material or Specifications: Oleo-pneumatic or spring-based, absorbing impact energy during landing and taxiing.
- Manufacturing Equipment: Hydraulic presses for oleo-pneumatic shock absorbers; spring forming equipment for spring-based shock absorbers.
- Process: Oleo-pneumatic shock absorbers are assembled and tested for sealing; spring-based shock absorbers are processed through spring manufacturing and assembly.

3.2.4.3 Wheels

- Material or Specifications: Aluminum alloy hubs with rubber tires, suitable for various ground conditions.
- Manufacturing Equipment: CNC lathes for aluminum alloy hub processing; tire molding equipment for rubber tires.
- Process: Aluminum alloy hubs are cast and machined; rubber tires are formed through vulcanization.

3.2.4.4 Retraction Mechanism

- Material or Specifications: Electric or hydraulic-driven, for retracting and extending the landing gear.
- Manufacturing Equipment: CNC milling machines for electric components; hydraulic equipment for hydraulic components.

- Process: Electric components are assembled and tested; hydraulic components are processed through hydraulic cylinder manufacturing and assembly.

3.2.5. Power Plant

3.2.5.1 Gasoline Engine

- Material or Specifications: Four-stroke gasoline engine, power range 5~30kW, displacement selected based on requirements.
- Manufacturing Equipment: Engine assembly line for overall assembly; CNC machining centers for component processing.
- Process: Engine block is cast and machined; crankshaft is forged and precision-machined; the entire engine is assembled, debugged, and calibrated.

3.2.5.2 Generator

- Material or Specifications: AC generator, power 1000~3000W, output voltage 28V AC.
- Manufacturing Equipment: Generator assembly equipment for overall assembly; winding equipment for stator winding.
- Process: Stator is wound and varnished; rotor is assembled and dynamically balanced; the entire unit is performance-tested.

3.2.5.3 DC Power Module

- Material or Specifications: Converts 28V AC to 24V DC, power >300W, efficiency ≥90%.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; power supply testing equipment for performance testing.
- Process: Circuit board is designed and etched; electronic components are soldered and debugged; the entire unit is performance-tested.

3.2.5.4 Propeller

- Material or Specifications: Glass fiber or carbon fiber composite, diameter 0.8~2 meters, fixed-pitch or variable-pitch.

- Manufacturing Equipment: CNC milling machines for aluminum alloy processing; composite material forming equipment for forming.
- Process: Glass fiber is formed through hand layup and curing; carbon fiber is processed through pre-preg forming and hot-press curing.

3.2.5.5 Fuel System

- Material or Specifications: High-density polyethylene (HDPE) fuel tank, fuel lines made of oil-resistant rubber.
- Manufacturing Equipment: Injection molding equipment for HDPE tanks; CNC milling machines for aluminum alloy fuel lines.
- Process: HDPE fuel tanks are formed through injection molding; fuel lines are processed through rubber forming and assembly.

3.2.5.6 Ignition System

- Material or Specifications: High-energy electronic ignition system with nickel alloy spark plugs.
- Manufacturing Equipment: Ignition system testing equipment for performance testing; electronic soldering equipment for electronic module assembly.
- Process: Electronic ignition modules are assembled and debugged; spark plugs are assembled and performance-tested.

3.2.5.7 Intake System

- Material or Specifications: Air filter made from high-performance polymer, intake pipes made from aluminum alloy or composite materials.
- Manufacturing Equipment: Injection molding equipment for air filters; CNC milling machines for intake pipes.
- Process: Air filters are formed through injection molding and assembly; intake pipes are processed through machining and surface treatment.

3.2.5.8 Exhaust System

- Material or Specifications: Stainless steel exhaust pipes, mufflers made from porous sound-absorbing materials.
- Manufacturing Equipment: CNC milling machines for exhaust pipe processing; welding equipment for muffler assembly.
- Process: Exhaust pipes are cut and welded; mufflers are assembled and performance-tested.

3.2.6. Control System

3.2.6.1 Flight Control Computer

- Material or Specifications: High-performance embedded processor, supporting multiple sensor interfaces.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; chip programming equipment for chip programming.
- Process: Circuit boards are designed and etched; chips are programmed and debugged; the entire unit is performance-tested.

3.2.6.2 Sensors (IMU, GPS, etc.)

- Material or Specifications: MEMS Inertial Measurement Unit (IMU) with accuracy ±0.1°; GPS module with positioning accuracy <1 meter.
- Manufacturing Equipment: Sensor calibration equipment for precision calibration; electronic soldering equipment for electronic module assembly.
- Process: IMU is calibrated and tested; GPS modules are assembled and performance-tested.

3.2.6.3 Servo Motors

- Material or Specifications: High torque density, fast response, operating voltage 24V.

- Manufacturing Equipment: Servo motor assembly equipment for overall assembly; motor test bench for performance testing.
- Process: Motors are wound and assembled; performance testing is conducted through torque and response speed tests.

3.2.6.4 Remote Control Receiver

- Material or Specifications: 2.4GHz frequency band, supporting multi-channel remote control signals.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; signal testing equipment for signal testing.
- Process: Circuit boards are assembled and debugged; signal testing is conducted through sensitivity and anti-interference tests.

3.2.7. Electrical System

3.2.7.1 Battery

- Material or Specifications: Lithium polymer battery, voltage 11.1V, capacity >10000mAh.
- Manufacturing Equipment: Battery packaging equipment for assembly; battery testing equipment for performance testing.
- Process: Batteries are assembled and performance-tested.

3.2.7.2 Power Management Module

- Material or Specifications: Distributes and manages electrical power, protects circuits, supports multiple power inputs.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; power supply testing equipment for performance testing.
- Process: Circuit boards are designed and etched; electronic components are soldered and debugged; the entire unit is performance-tested.

3.2.7.3 Electronic Speed Controller (ESC)

- Material or Specifications: Controls engine speed (for electric drones) or servo motor movement.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; motor testing equipment for performance testing.
- Process: Circuit boards are assembled and debugged; performance testing is conducted through motor control tests.

3.2.8. Other Components

3.2.8.1 Antenna

- Material or Specifications: High-gain antenna, operating frequency band 1.2GHz~5.8GHz.
- Manufacturing Equipment: Antenna testing equipment for performance testing; electronic soldering equipment for electronic module assembly.
- Process: Antennas are designed and assembled; performance testing is conducted through signal strength and transmission distance tests.

3.2.8.2 Lighting System

- Material or Specifications: LED navigation lights and landing lights, operating voltage 24V.
- Manufacturing Equipment: Electronic soldering equipment for circuit board assembly; lighting fixture testing equipment for performance testing.
- Process: Lighting fixtures are assembled and debugged; performance testing is conducted through brightness and reliability tests.

3.2.8.3 Payload Devices (Optional)

- Material or Specifications: Based on mission requirements, can carry cameras, radars, sensors, etc.
- Manufacturing Equipment: CNC milling machines for metal component processing;

composite material forming equipment for composite components.

- Process: Metal components are processed through mechanical machining and welding; composite components are formed through mold shaping and curing.

3.3. Carbon Fiber Materials and Their Characteristics

3.3.1. Types of Carbon Fiber Materials

3.3.1.1 Carbon Fiber Fabric

Carbon fiber fabric is a foundational material for structural components of drones. It features high strength, low weight, corrosion resistance, and excellent thermal stability. It is commonly used to manufacture wings, fuselage frames, and other critical load-bearing parts. Through precise cutting and sewing processes, it can be shaped into various forms and sizes to meet the diverse design requirements of drones.

3.3.1.2 Carbon Fiber Prepreg

Carbon fiber prepreg is made by impregnating carbon fiber fabric with a specific type of resin under strictly controlled conditions. This material, once cured, forms structural components with high strength, high modulus, and excellent fatigue resistance. It is often used to create complex parts such as landing gear, engine mounts, and battery compartments.

3.3.1.3 Carbon Fiber Composite

Carbon fiber composites are made by combining carbon fibers with resin matrices. They offer superior mechanical properties and durability. These materials are widely used in the skin, wings, tail sections, landing gear, and other parts of drones.

3.3.2. Characteristics of Carbon Fiber Materials

3.3.2.1 Lightweight and High Strength

Carbon fiber materials have a density of only 1.6 g/cm^3—just one-fourth the weight of steel, yet their strength exceeds that of steel by four times. This characteristic allows drones to significantly reduce weight while maintaining high strength and rigidity, thereby improving endurance and flight efficiency.

3.3.2.2 Corrosion and Heat Resistance

Carbon fiber composites exhibit excellent corrosion resistance and do not react chemically with acids, bases, or salts. They also maintain good mechanical properties in high-temperature environments without creeping or fatiguing. These characteristics ensure the stability and safety of drones in various harsh environments.

3.3.2.3 High Fatigue and Impact Resistance

The fatigue limit of carbon fiber composites can reach 70%–80% of their tensile strength, significantly higher than most metallic materials. This means drones can achieve higher reliability and service life under long-term use and complex operating conditions.

3.3.2.4 Design Flexibility

Carbon fiber composites are anisotropic, meaning their properties can be tailored through rational layering and structural optimization to meet the mechanical requirements of drones in different directions. Additionally, carbon fiber materials can be formed into large, integrated structures through processes like molding and autoclave curing, reducing the number of parts, simplifying the structure, and enhancing overall stability.

3.3.2.5 Aesthetic Appeal

The black woven pattern of carbon fiber materials is visually appealing and popular among younger users. Moreover, carbon fiber skins are smooth, accurately shaped, and symmetrical, reducing air resistance and improving flight speed and efficiency.

3.3.3. Applications of Carbon Fiber Materials in Drones

3.3.3.1 Fuselage Structure

Carbon fiber composites are used in the fuselage structure of drones to significantly reduce weight while enhancing structural strength and rigidity. For example, a drone manufacturer reported a weight reduction of 25%–30% after using carbon fiber materials.

3.3.3.2 Wings and Tail Sections

The high strength and lightweight characteristics of carbon fiber composites provide sufficient lift and excellent control performance for wings and tail sections. Through rational layering design, these parts can meet the mechanical requirements in different directions, improving the stability and maneuverability of drones.

3.3.3.3 Skin

Carbon fiber skins are smooth and accurately shaped, reducing air resistance and improving flight speed and efficiency. Additionally, their excellent fatigue resistance and durability ensure the stability of drones during long-term missions.

3.3.3.4 Landing Gear

Landing gear must withstand significant impact loads. Carbon fiber composites, through rational structural design (e.g., using honeycomb core structures), not only reduce weight but also enhance energy absorption and shock mitigation, ensuring the safety of drones during landing.

3.3.3.5 Rotors and Propellers

For multi-rotor drones, carbon fiber composites can be used to manufacture lightweight and robust rotors and propellers. These components reduce air resistance and improve lift efficiency. The fatigue resistance of carbon fiber materials also ensures the stability and reliability of drones during long-term flights.

3.3.3.6 Battery and Fuel Tanks

Carbon fiber materials are used for battery and fuel tanks due to their lightweight, high strength, and corrosion resistance. These characteristics help reduce the overall weight of drones while ensuring the stable operation of these critical components in harsh environments.

3.3.3.7 Connectors

Carbon fiber composites offer excellent connection properties and can be securely joined to other components through various methods (e.g., bolted or riveted connections). This ensures the overall structural stability of drones.

3.4.1 The types of carbon fiber fabric cutting equipment

Equipment Type	Features	Application Scenarios
CNC Oscillating Knife Cutter	Suitable for various non-metal materials, including carbon fiber and glass fiber fabrics. Fast cutting speed, up to 1400 mm/s. High precision, with a cutting accuracy of ±0.01 mm. Environmentally friendly, with no high temperatures, smoke, or odors. Equipped with a vacuum adsorption system to securely hold the material.	Ideal for cutting complex shapes and high-precision requirements, such as for drone shells and wings.
Laser Cutter	Uses high-energy laser beams to melt and cut carbon fiber. Capable of cutting complex shapes with a smooth surface finish. Suitable for high-precision processing, avoiding material delamination.	Ideal for high-precision, complex shape cutting, especially for small batch production.
Waterjet Cutter	Uses high-speed water jets for cutting, with no dust pollution. Capable of cutting complex shapes and suitable for mass production.	Ideal for cutting large areas of carbon fiber fabric, especially in scenarios with high environmental requirements.
Vibrating Knife Cutter	Suitable for cutting flexible materials like carbon fiber fabric. Features automatic material feeding and vacuum adsorption to improve cutting efficiency. High cutting precision and easy operation.	Ideal for cutting carbon fiber fabric with medium precision requirements, suitable for large-scale production.
Ultrasonic Cutter	Uses ultrasonic frequency vibrations to cut. High cutting precision, suitable for fine processing.	Ideal for high-precision, small-sized carbon fiber fabric cutting.

Manual Cutting Tools	Low cost and easy to operate. Suitable for simple straight-line cutting.	Ideal for cutting small-sized carbon fiber fabric with low precision requirements.

3.4.2 CNC Balsa Wood Laser Cutting Machine

Item	**Parameter**
Machine Type	CNC Laser Cutting Machine
Material Suitable	Balsa Wood
Laser Type	CO_2 Laser, Semiconductor Laser
Laser Power	80W - 300W
Laser Wavelength	CO_2 Laser: 10.6μm; Semiconductor Laser: Depending on the specific model, common wavelengths range from 800nm to 980nm
Maximum Cutting Speed	1400 mm/s
Minimum Line Width	0.1 mm
Cutting Thickness Range	1 - 20 mm
Positioning Accuracy	≤±0.01 mm
Working Area	900×600 mm to 1600×2600 mm
Drive System	Servo Motor and Driver

Cooling System	Chiller (for CO_2 Laser)
Control System	CNC Control System, supports complex path planning
Software Support	Supports BMP, AI, DST, CDR, PLT, DXF formats
Environmental Requirements	Clean, temperature-controlled, and humidity-controlled
Maintenance Requirements	Regular cleaning of optical components, calibration of the machine

3.4.3 Carbon Fiber Composite Materials

Component	**Primary Function**	**Common Materials**	**Characteristics**
Carbon Fiber (Reinforcement)	Provides high strength, high modulus, and primary load-bearing capability	High-strength carbon fiber, high-modulus carbon fiber	High strength, high modulus, low density, high-temperature resistance, corrosion resistance, fatigue resistance
Resin Matrix	Bonds carbon fibers, transfers loads, and provides environmental protection	Epoxy resin, bismaleimide resin (BMI), polyether ether ketone (PEEK)	Good adhesion, mechanical properties, chemical resistance, high-temperature resistance
Curing Agent	Promotes resin curing to form a stable structure	Aromatic polyamines, dicyandiamide, anhydride curing agents	Provides different curing temperatures and thermal resistance

Surfactant/Size	Improves wetting and dispersion of carbon fibers in the resin, enhances interfacial bonding strength	Polyimide (PI) size	Improves interlaminar shear strength and interfacial properties
Auxiliary Reinforcement Materials	Optimizes composite performance, reduces cost, or enhances impact resistance	Glass fiber, aramid fiber, carbon nanotubes, graphene	Enhances impact resistance, fatigue resistance, electrical conductivity, or reduces cost
Other Additives	Enhances fire resistance, oxidation resistance, and weather resistance of the composite	Flame retardants, antioxidants, UV absorbers	Improves fire resistance, weather resistance, and service life

3.4.4 Molding Temperature, Pressure, and Vacuum Degree for Carbon Fiber Composite Materials (for Reference)

Parameter	Range	Description
Molding Temperature	60°C - 180°C	Low-temperature curing is typically between 60°C - 90°C, suitable for out-of-autoclave (OOA) processes. Medium to high-temperature curing is generally between 120°C - 180°C.
Molding Pressure	0.5 MPa - 25 MPa	Vacuum bag molding typically uses a pressure of 0.5 MPa - 0.7 MPa. Autoclave molding generally uses a pressure of 0.7 MPa. For SMC (Sheet Molding Compound) molding of carbon fiber, the pressure range is 10 MPa - 25 MPa.

Vacuum Degree	-0.05 MPa - -0.1 MPa	During vacuum bag curing, the vacuum degree is generally between -0.05 MPa and -0.09 MPa. For autoclave curing, the vacuum degree can reach -0.1 MPa.

Note: Regarding molding time, the appropriate temperature and time curves should be selected based on material data.

3.5. Surface Treatment Process Table for Carbon Fiber Composite Materials after Molding

No.	Process Step	Specific Operation	Notes
1	Sanding	Use sandpaper (400# - 800#) to sand the surface of the molded carbon fiber composite material, removing burrs and uneven areas.	Sand in the direction of the fiber to avoid damaging the carbon fibers.
2	Cleaning	Wipe the surface with a lint-free cloth dampened with alcohol or a dedicated cleaner to remove dust and impurities from sanding.	Ensure the surface is free of oil and dust, and keep the cleaning cloth clean.
3	Filling with Putty	Apply specialized putty to fill holes and gaps on the surface, making it smooth and flat.	Apply putty evenly with an appropriate thickness to avoid cracking due to excessive thickness.
4	Putty Curing	Cure at room temperature for 24 hours, or follow the putty instructions for heat curing.	Avoid contact with dust and impurities during the curing process.
5	Sanding Putty	Use sandpaper (800# - 1200#) to sand the cured putty, making the surface smooth and flat.	Clean the surface again after sanding to ensure no residual putty particles remain.

6	Pre-painting Treatment	Use a spray gun to apply primer to enhance surface adhesion and corrosion resistance.	Apply primer evenly with an appropriate thickness to avoid sagging.
7	Painting	Use a spray gun to apply topcoat, selecting the appropriate color and coating thickness according to design requirements.	The painting environment should be dust-free, with a spray distance of 15-20 cm, and even application.
8	Paint Curing	Cure at room temperature for 24 hours, or follow the paint instructions for heat curing (usually 60℃ - 80℃, 1 - 2 hours).	Avoid contact with dust and impurities during the curing process to ensure a smooth paint surface.
9	Polishing	Use a polisher or hand-polishing to remove minor scratches on the paint surface, achieving a mirror-like finish.	Apply even pressure during polishing to avoid local overheating or paint surface damage.

3.6. Manufacturing Process Table for PMI Foam and Prepreg Carbon Fiber Propellers using a Constant-Temperature Press

No.	**Process Step**	**Specific Operation**	**Notes**
1	Mold Preparation	Design and manufacture metal molds that match the shape of the propeller. The molds should have good thermal conductivity.	Ensure mold accuracy and surface quality. Clean the mold cavity thoroughly to remove any impurities.
2	Prepreg Layup	Lay up carbon fiber prepreg inside the mold to form the skin of the propeller.	Pay attention to fiber orientation and layering sequence during layup to avoid wrinkles and air bubbles.

3	PMI Foam Placement	Place PMI foam as the core material between layers of prepreg.	Ensure that the PMI foam matches the dimensions of the prepreg and maintain its flatness and integrity.
4	Preforming	Preliminarily fix the laid-up prepreg and PMI foam to form a preform.	Use elastic bands or vacuum bags to preliminarily fix the layers, ensuring tight bonding between them.
5	Press Molding	Place the preform into the constant-temperature press, set the temperature at 180℃±6℃, and the pressure at 0.5-1.0 MPa for molding.	Maintain stable temperature and pressure during molding to avoid local overheating or insufficient pressure.
6	Curing	Keep the set temperature and pressure in the press for a curing time of 2-4 hours.	Adjust curing time based on the characteristics of the prepreg and foam to ensure complete curing.
7	Demolding and Inspection	Carefully demold after curing and inspect the surface quality and dimensional accuracy of the propeller.	Avoid using excessive force during demolding to prevent damage to the propeller surface.
8	Post-processing	Perform surface sanding, cleaning, and necessary machining on the molded propeller.	Ensure the balance and dimensional accuracy of the propeller, and remove excess material.

3.7. Injection Molding Process Table for Carbon Fiber-Modified Materials

No.	**Process Step**	**Specific Operation**	**Notes**
1	Material Preparation	Select appropriate carbon fiber-modified materials, such as continuous carbon fiber-	Ensure the material properties meet the design requirements, such as strength and modulus.

		reinforced thermoplastic composites.	
2	Drying Treatment	Dry the carbon fiber-modified material in an oven at 80°C - 120°C for 2 - 4 hours.	Avoid moisture absorption during drying to ensure the material's flowability during injection molding.
3	Injection Molding Machine Preparation	Set the injection molding machine's temperature, pressure, and injection speed according to the material characteristics.	Temperature is generally set at 250°C - 300°C, with an injection pressure of 100 - 150 MPa.
4	Injection Molding	Add the dried carbon fiber-modified material to the hopper of the injection molding machine and proceed with molding.	Control the injection speed to avoid air bubbles or burning within the mold.
5	Cooling and Solidifying	Allow the molded part to cool to room temperature inside the mold, ensuring complete solidification.	Adjust cooling time based on the thickness of the molded part and material characteristics.
6	Demolding and Inspection	Carefully demold and inspect the surface quality and dimensional accuracy of the molded part.	Avoid using excessive force to prevent damage to the molded part, ensuring it meets the design requirements.
7	Post-processing	Perform necessary post-processing on the molded part, such as sanding or painting.	Ensure the surface quality of the molded part meets subsequent usage requirements.

3.8. PCB & PCBA Manufacturing Process

3.8.1 PCB Manufacturing Process

No.	**Process Step**	**Specific Operation**	**Notes**

1	Circuit Design	Use CAD software to generate the circuit design, specifying component layout and routing.	Consider component dimensions and electrical performance to ensure functionality.
2	Patterning	Apply photosensitive material to the copper layer, expose and develop it, then etch away unwanted copper to form the circuit traces.	Control etching time and temperature to avoid over-etching or under-etching of the traces.
3	Drilling	Drill through holes using mechanical or laser drilling to connect layers.	Drilling quality affects PCB performance; control drilling parameters.
4	Electroplating	Electroplate the through holes and pads to enhance conductivity and solderability.	Ensure uniform plating thickness to avoid poor soldering or contact issues.
5	Solder Mask Application	Apply solder mask to the PCB surface to protect the copper and prevent solder bridging.	Ensure uniform application, avoiding coverage of pads.
6	Surface Treatment	Perform surface treatment on pads, such as Hot Air Solder Leveling (HASL) or Electroless Nickel Immersion Gold (ENIG).	Choose the appropriate surface treatment method based on requirements.
7	Silkscreen Printing	Use screen printing to apply legends on the PCB, marking component positions and other information.	Ensure clear and accurate legends.
8	Cutting	Use a CNC system to cut the manufacturing panel into individual PCBs.	Cutting precision affects PCB dimensions and appearance.

9	Electrical Testing	Conduct electrical testing on the PCB using a bed-of-nails adapter or flying probe tester.	Ensure high test coverage to detect short circuits, open circuits, etc.

3.8.2 PCBA Manufacturing Process

No.	Process Step	Specific Operation	Notes
1	Solder Paste Printing	Apply solder paste to the pads on the PCB.	Ensure uniform solder paste thickness, avoiding missing or excess paste.
2	SPI Inspection	Inspect the quality of solder paste printing, checking for fullness, uniformity, and alignment.	Detect and address solder paste printing anomalies promptly.
3	Pick and Place (SMT)	Use a pick-and-place machine to mount components onto the PCB.	Achieve high placement accuracy to avoid component misalignment or missing parts.
4	Reflow Soldering	Pass the assembled PCB through a reflow oven to complete the soldering process.	Control the oven temperature profile to ensure soldering quality.
5	AOI Inspection	Conduct automated optical inspection on the soldered PCB.	Detect soldering defects such as solder bridging and cold solder joints promptly.
6	Through-hole Insertion (THT)	Insert through-hole components into the PCB.	Ensure accurate insertion to avoid component damage.
7	Wave Soldering	Perform wave soldering on through-hole components.	Control soldering temperature and time to avoid poor soldering.

8	Cleaning	Remove solder residue using cleaning agents or cleaning equipment.	Ensure thorough cleaning to avoid residue affecting performance.
9	ICT Testing	Conduct electrical performance testing on the PCBA.	Ensure high test coverage to detect faults promptly.
10	Functional Testing (FCT)	Perform functional testing on the PCBA to verify if it meets design requirements.	Simulate actual usage scenarios to ensure proper functionality.
11	Burn-in Testing	Conduct burn-in testing on the PCBA under simulated harsh conditions.	Eliminate early failures to ensure reliability.
12	Assembly and Packaging	Assemble the PCBA into the final product and package it.	Ensure assembly quality, and use anti-static and moisture-proof packaging.

3.9. Common Electronic Components Used in PCBA Assembly

No.	**Component Name**	**Primary Function**	**Common Types**	**Application Scenarios**
1	Resistor	Voltage division, current limiting, and current sharing	Fixed resistors, variable resistors (potentiometers), surface-mount resistors	Power circuits, signal processing circuits, sensor circuits
2	Capacitor	Energy storage, filtering, coupling, and DC blocking	Surface-mount capacitors (MLCC), electrolytic capacitors, ceramic capacitors	Power filtering, decoupling, signal coupling

3	Inductor	Magnetic energy storage, filtering, and oscillation	Surface-mount inductors, core inductors, air-core inductors	Power circuits, filter circuits, wireless communication
4	Diode	Unidirectional conduction, rectification, voltage regulation	General diodes, Zener diodes, light-emitting diodes (LEDs)	Power rectification, voltage regulation circuits, indicator lights
5	Transistor	Signal amplification, electronic switching	NPN, PNP, surface-mount transistors	Amplifier circuits, drive circuits, switch-mode power supplies
6	Field-Effect Transistor (FET)	Signal amplification, switch control	MOSFET, JFET	High-frequency circuits, digital circuits, power control
7	Transformer	Voltage transformation, current transformation, impedance matching	Power transformers, isolation transformers	Power adapters, signal isolation
8	Electroacoustic Devices	Conversion between electrical and sound signals	Speakers, microphones, headphones	Audio devices, communication equipment

9	Photoelectric Devices	Photoelectric conversion	Photoresistors, LEDs, optocouplers	Displays, sensors, communication
10	Display Devices	Conversion of electrical signals to optical signals	LED displays, LCD displays	Consumer electronics, industrial control
11	Sensors	Detection of physical quantities and conversion to electrical signals	Temperature sensors, pressure sensors, light sensors	Smart devices, automated control
12	Integrated Circuits (ICs)	Implementation of complex circuit functions	Microcontrollers (MCUs), operational amplifiers	Embedded systems, signal processing
13	Crystal Oscillator	Providing stable clock signals	Quartz crystals, ceramic resonators	Microcontrollers, communication equipment
14	Thyristor	Power control, rectification	Unidirectional thyristors, bidirectional thyristors	Power control, motor speed control
15	Connector	Electrical connection	Header pins, header sockets, USB connectors	Internal connections in electronic devices, external interfaces

3.10. Material and Manufacturing Process Table for Carbon Fiber Composite Molds

No.	Process Step	Specific Operation	Notes
1	Mold Design	Design the mold using CAD software based on the shape and size requirements of the carbon fiber composite part.	Consider draft angles, venting channels, and layout of cooling/heating systems in the design.
2	Material Selection	Choose mold materials suitable for carbon fiber composite molding, such as aluminum alloy, steel, graphite, or composite molds.	Aluminum alloy is suitable for lightweight and rapid prototyping; steel is used for high-precision and high-volume production; graphite and composite molds are ideal for complex shapes and high-temperature molding.
3	Mold Machining	Use CNC machining centers or precision machine tools to machine the mold cavity and core.	Ensure machining accuracy with a surface roughness of the cavity reaching below Ra0.8.
4	Heat Treatment	Perform heat treatment processes such as quenching and tempering on steel molds to enhance hardness and wear resistance.	The hardness of heat-treated molds should generally reach above HRC45.
5	Surface Treatment	Polish, hard chrome plate, or apply release agents to the working surfaces of the mold.	The polished mold surface should be smooth and flawless, and hard chrome plating can improve wear and corrosion resistance.
6	Mold Assembly	Assemble the machined mold cavity and core to	Strictly control the gaps and positioning accuracy during assembly.

		ensure mold accuracy and sealing performance.	
7	Mold Testing	Conduct a trial run of the mold before actual production to check the molding effect and demolding performance.	Adjust and modify the mold as necessary based on the trial results.
8	Mold Acceptance	Inspect the mold to ensure it meets all performance requirements after successful testing.	Check the mold's dimensional accuracy, surface quality, and demolding performance during acceptance.

3.11. Gasoline Engine Assembly and Testing Process

No.	Process Step	Specific Operation	Notes
1	Component Cleaning	Use specialized cleaning agents and equipment to clean all engine components, removing oil, metal shavings, and impurities.	Ensure that component surfaces are free of residues and thoroughly dried after cleaning.
2	Cylinder Block Assembly	Install pistons, connecting rods, crankshafts, and other components into the cylinder block, ensuring correct installation of piston rings and proper tightening of connecting rod bolts.	Tighten connecting rod bolts and crankshaft bearing cap bolts according to specified torque values to avoid over-tightening or under-tightening.

3	Cylinder Head Assembly	Install valves, valve springs, valve seats, and other components, ensuring valve clearances meet design requirements.	Use specialized tools to adjust valve clearances and ensure valve sealing.
4	Lubrication System Assembly	Install the oil pump, oil filter, oil cooler, and other components, ensuring the lubrication system is unobstructed.	Check the installation position and sealing of the oil pump to ensure no leakage.
5	Cooling System Assembly	Install the water pump, radiator, thermostat, and other components, ensuring the cooling system's sealing and cooling performance.	Check the installation position and sealing of the water pump to ensure no leakage.
6	Ignition System Assembly	Install spark plugs, ignition coils, distributor, and other components, ensuring the ignition system operates normally.	Check spark plug gaps and ignition coil connections to ensure correct firing order.
7	Fuel System Assembly	Install the fuel pump, fuel injectors, fuel filter, and other components, ensuring the fuel system is leak-free.	Check the installation position and sealing of the fuel pump to ensure normal fuel supply.
8	Engine Final Assembly	Assemble all subsystems onto the engine block, ensuring all components	Tighten all bolts according to specified torque values to ensure overall engine stability.

		are properly installed and tightened.	
9	Engine Testing (Cold Run)	Conduct a cold run test to check the engine's sealing, lubrication, and cooling performance.	Monitor oil pressure, coolant temperature, and engine speed to ensure no abnormalities.
10	Engine Testing (Hot Run)	Run the engine at low and medium speeds to check performance and stability.	Monitor engine power, torque, and fuel consumption to ensure performance meets design requirements.
11	Performance Testing	Use an engine test bench to conduct performance tests, including power, torque, and fuel economy.	Record test data and analyze whether engine performance meets design standards.
12	Final Inspection	Conduct a comprehensive inspection of the engine to ensure no leaks, abnormal noises, or vibrations.	Inspect the engine's appearance and operating condition to ensure it meets quality standards.

3.12. CNC Machining Equipment for Aluminum Alloy Components

Equipment Type	**Functions and Features**
CNC Machining Centers	Used for multi-axis machining, capable of performing complex milling, drilling, and tapping operations. Suitable for high-precision and complex-shaped aluminum alloy parts.
CNC Lathes	Primarily used for machining rotary components, such as turning aluminum alloy tubes or shafts. Capable of achieving high-precision external and internal machining.
CNC Milling Machines	Used for machining planes, slots, and complex contours. Suitable for aluminum alloy sheets and profiles, offering high efficiency and precision.

CNC Drilling Machines	Specifically designed for drilling operations, with precise control over drilling positions and depths. Suitable for hole machining in aluminum alloy parts.
Laser Cutting Machines	Utilize laser beams to cut aluminum alloy materials, suitable for complex shapes and high-precision requirements.
Grinding Machines	Used for precision finishing of aluminum alloy parts to improve surface finish and dimensional accuracy.

3.13. Carbon Fiber 3D Printer Specifications

Parameter	**Specifications**
Printing Technology	FDM/FFF (Fused Filament Fabrication)
Printing Dimensions	Single nozzle: 330×240×240 mm Dual nozzles: 295×240×240 mm
Maximum Build Volume	600×450×500 mm (for some industrial-grade devices)
Nozzle Temperature	Up to 330°C; some high-performance devices reach 395°C
Bed Temperature	Up to 110°C; some devices support 120°C
Layer Thickness Range	0.05 - 0.3 mm
Printing Accuracy	±0.2 mm
Nozzle Type	Supports dual nozzles for resin and pre-impregnated materials
Material Compatibility	Continuous carbon fiber, chopped carbon fiber, nylon, PETG, PEEK, etc.
Machine Dimensions	607×596×465 mm
Machine Weight	Approximately 48 kg

Applications	Aerospace, automotive components, high-performance tools, lightweight structures
Advantages	High strength, lightweight, high-temperature resistance, corrosion resistance

3.14. CMM (Coordinate Measuring Machine) and Industrial CT Equipment Parameters

Parameter Category	CMM Equipment	Industrial CT Equipment
Measurement Range	300×200×200 mm (small-scale equipment) 1000×1500×800 mm (mid-scale equipment) 2000×3000×1000 mm (large-scale equipment)	Maximum volume for 3D scanning: φ290mm×400mm Maximum test piece diameter×height: 360mm×600mm
Measurement Accuracy	±(2.5 + L/300) μm (small-scale equipment) ±(5 + L/200) μm (large-scale equipment)	Geometric measurement accuracy: The absolute error between the measured geometric dimensions of an object on the CT image and its actual dimensions
Probe/X-ray Source	Contact probes, optical probes, laser scanning probes	X-ray tube (micro-focus tube): 300kV/3mA X-ray tube (nano-focus tube): 180kV/0.8mA
Scanning Mode	-	2nd generation scanning, 3rd generation scanning
Image Reconstruction Time	-	Generally no more than 3 seconds
Resolution Capability	-	Spatial resolution: The ability to distinguish the smallest structural details from a CT image Density resolution: The

		ability to distinguish the smallest density differences from a CT image
Additional Features	-	Equipped with Digital Radiography (DR) functionality

3.15. High and Low Temperature Testing Equipment

Parameter Category	**Specifications**
Equipment Name	High and Low Temperature Test Chamber
Temperature Range	-70°C to +150°C; some models reach -90°C to +200°C
Humidity Range	20% to 98% RH
Temperature Accuracy	±0.5°C
Humidity Accuracy	±2% RH
Control Method	P.I.D + S.S.R system for coordinated control
Refrigeration System	Full-sealed compressor, environmentally friendly refrigerants (e.g., R404A, R23)
Heating System	Independent heating system, non-interfering with low-temperature tests
Safety Protection	Over-temperature protection, fan overheating protection, power phase loss protection, etc.
Application Fields	Electronics, automotive, aerospace, medical devices, material research, etc.

3.16. Equipment for Product Performance Testing after Assembly

Test Item	**Test Content**	**Test Method**

Mechanical Connection Check	Inspect the mechanical connections of the bus interface, including bolts, connectors, and sockets.	Use tools to check the tightness of connections to ensure there is no looseness.
Control Check	Verify the control functions of the bus, including signal transmission and response to control commands.	Conduct control test modes to validate the device's ability to receive and execute control signals.
Communication Check	Assess the communication performance of the bus, including data transmission accuracy and integrity.	Use communication testing software to monitor error rates and packet loss during data transmission.
Safety Regulation (Safety) Check	Evaluate the electrical safety of the product, including insulation resistance, dielectric withstand voltage, and leakage current tests.	Utilize safety testing equipment to conduct tests in accordance with relevant standards (e.g., IEC 60529).
Waterproof Rating Test	Assess the waterproof performance of the product's enclosure based on the IP rating.	Use waterproof testing equipment to perform tests such as water spraying and immersion in accordance with IP rating standards (e.g., IPX1 to IPX8).

3.17. Automated Vertical Warehouses and Climate-Controlled Storage

1. Automated Vertical Warehouse

- Definition: An automated vertical warehouse is a highly efficient storage system that utilizes high-rise shelving, automated stacker cranes, and conveying systems to achieve automated storage and retrieval of goods.
- Key Features:

- High Space Utilization: Maximizes vertical space through high-rise shelving.
- Automated Operation: Equipped with automated stacker cranes and conveying systems to reduce manual labor and increase efficiency.
- Integrated Management System: Incorporates a Warehouse Management System (WMS) to enable real-time monitoring and inventory management.

- Applications: Suitable for logistics centers, manufacturing plants, e-commerce warehouses, and other scenarios with high storage volumes and turnover rates.

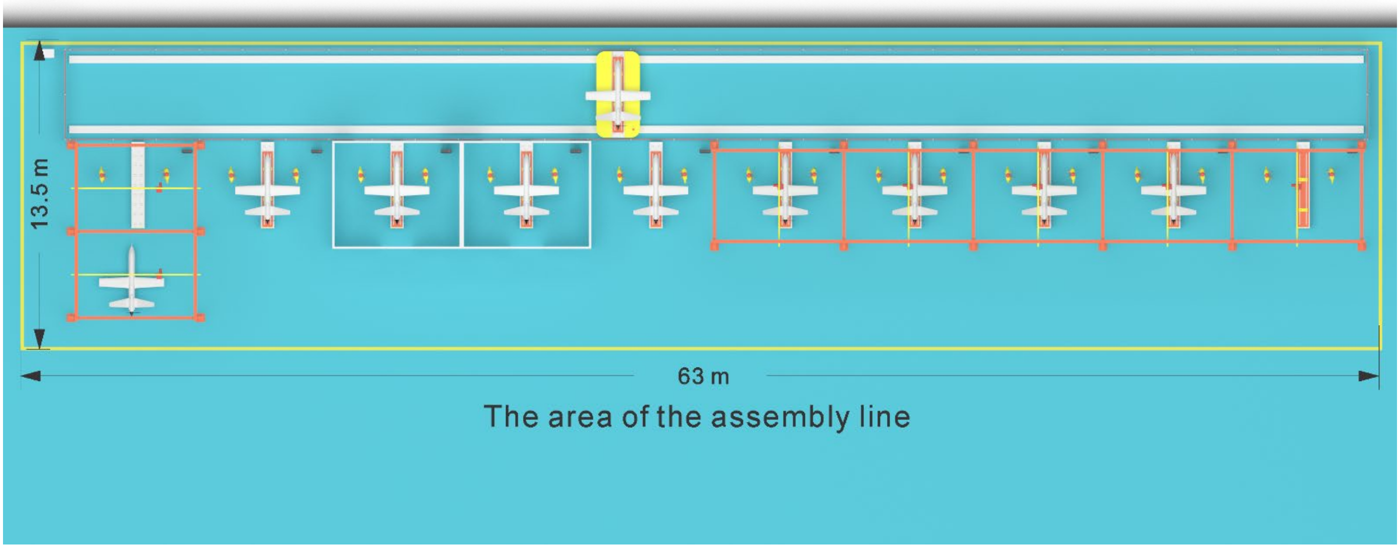
2. Climate-Controlled Storage

- Definition: Climate-controlled storage facilities maintain stable temperature and humidity levels within the warehouse using air conditioning systems and humidity control equipment.
- Key Features:
  - Temperature Control: Maintains a stable temperature range, typically between 18°C and 25°C.
  - Humidity Control: Keeps humidity levels stable, usually between 40% and 60% RH.
  - High-Precision Control: Equipped with high-precision temperature and humidity sensors and automated control systems to ensure environmental stability.
- Applications: Ideal for storing items with high environmental requirements, such as electronics, pharmaceuticals, precision instruments, and archival materials.

Parameter Category	**Automated Vertical Warehouse**	**Climate-Controlled Storage**
Primary Function	Automated storage and retrieval, high space utilization	Temperature and humidity control
Space Utilization	High (vertical space utilization)	Medium (planar layout)
Automation Level	High (stacker cranes, conveying systems)	Medium (climate control systems)

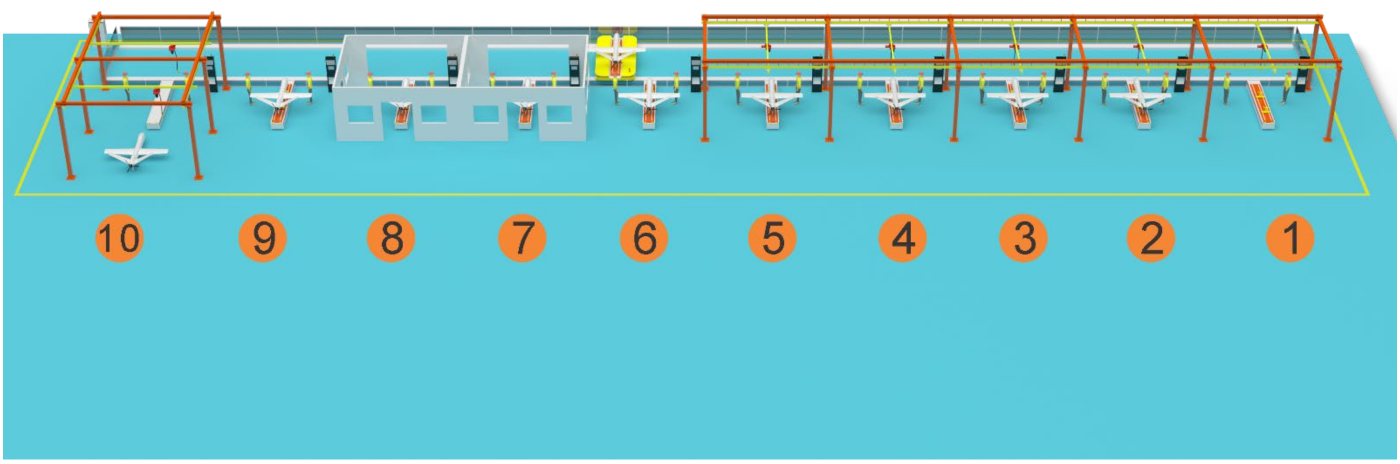
Applications	Logistics centers, manufacturing, e-commerce warehouses	Electronics, pharmaceuticals, archival materials
Temperature Range	-	18°C - 25°C
Humidity Range	-	40% - 60% RH
System Integration	Integrated Warehouse Management System (WMS)	Integrated climate control system

4. Final Assembly Production Line

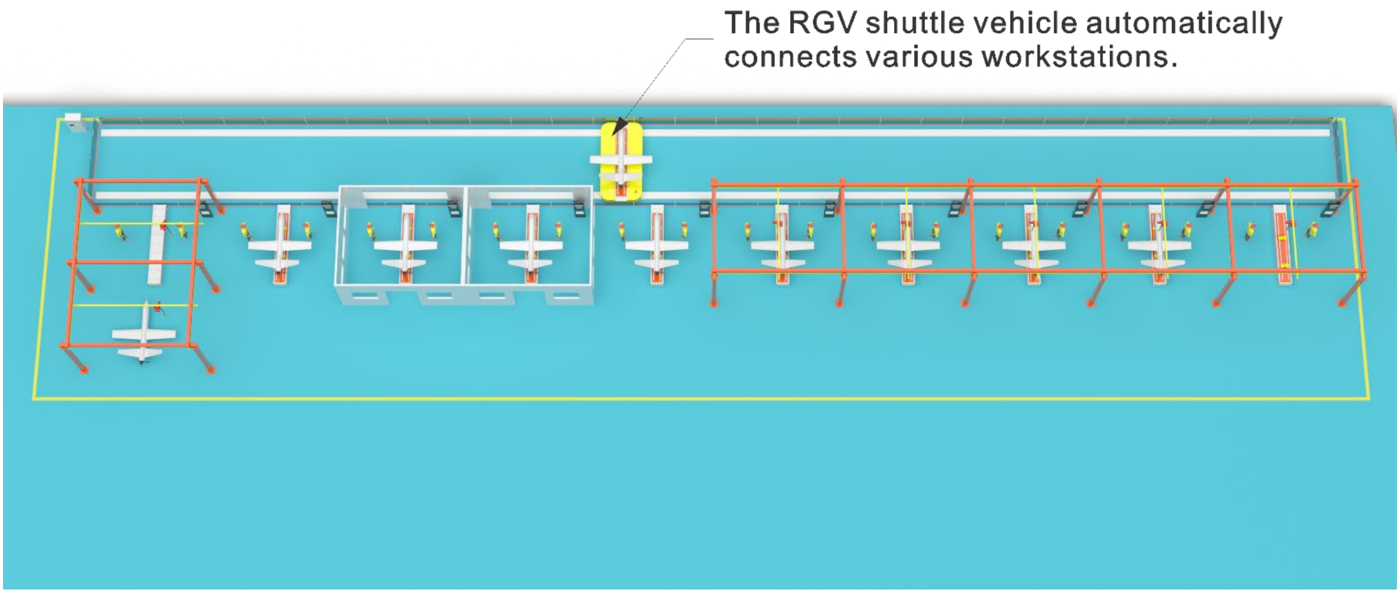


Design capacity per assembly line: 25 sets of agricultural machinery per day (8 hours).

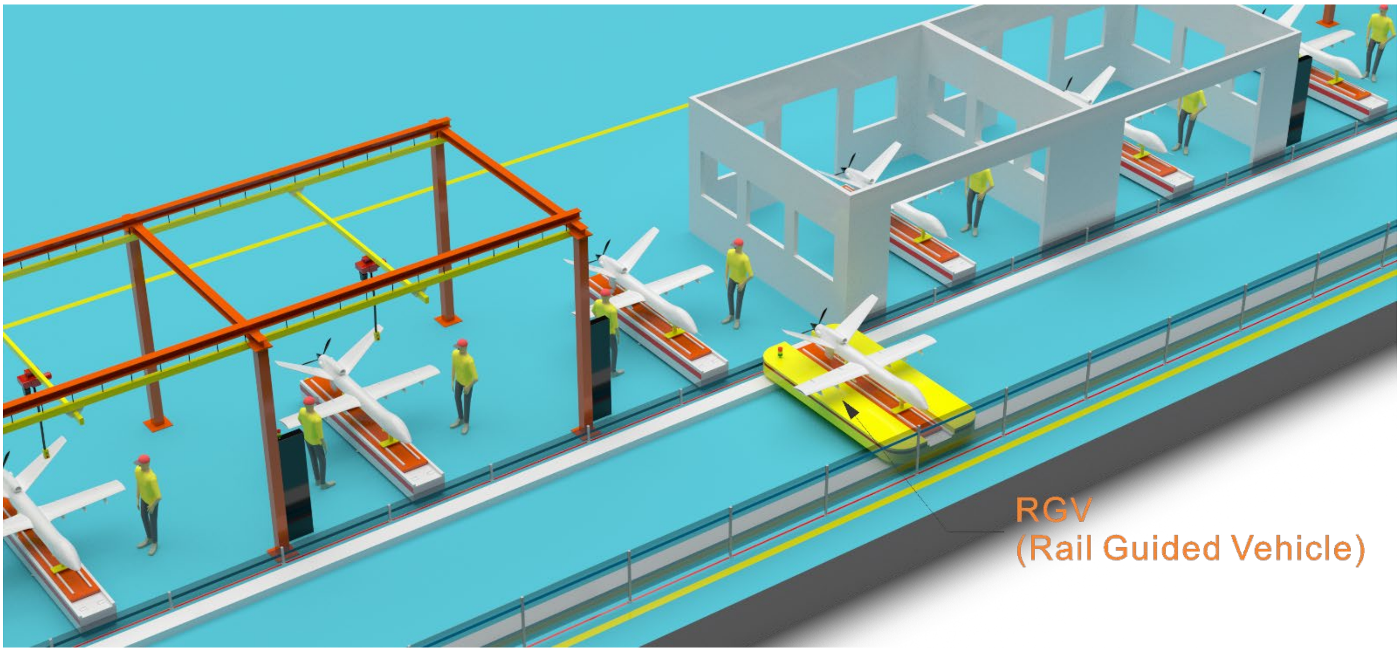
Workstations of Assembly line



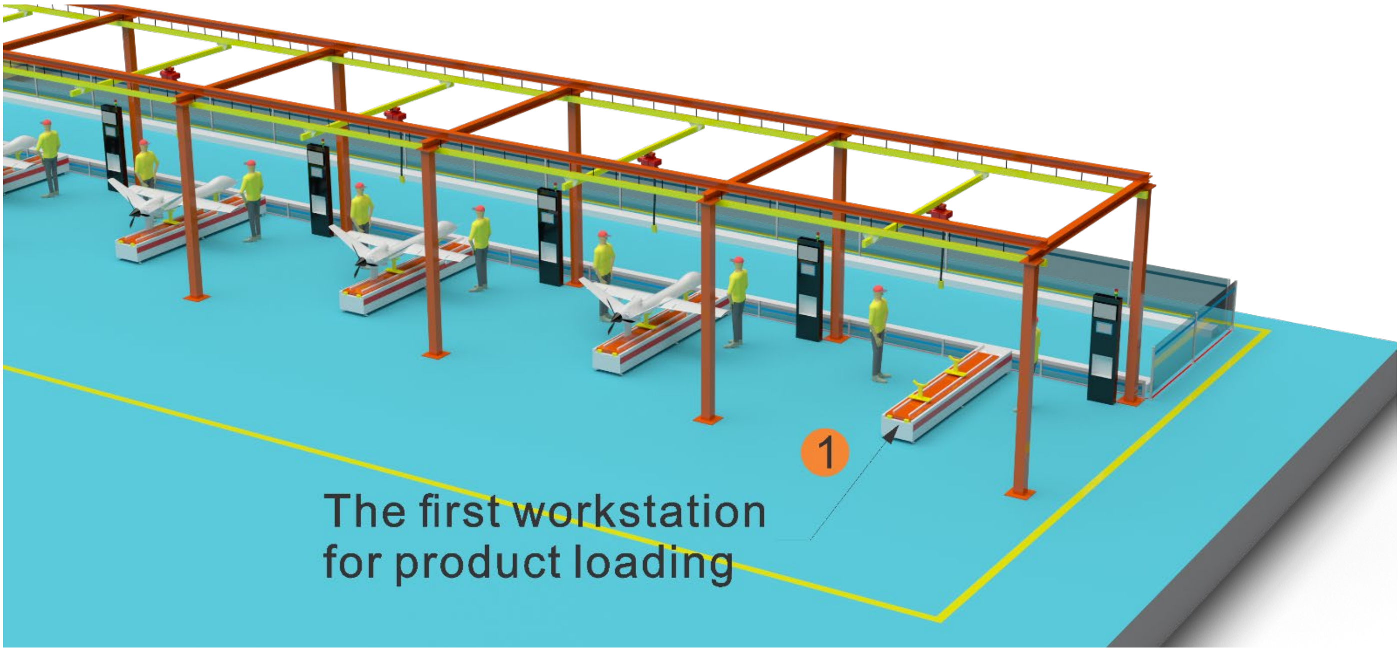
Each assembly line consists of 10 operating stations.



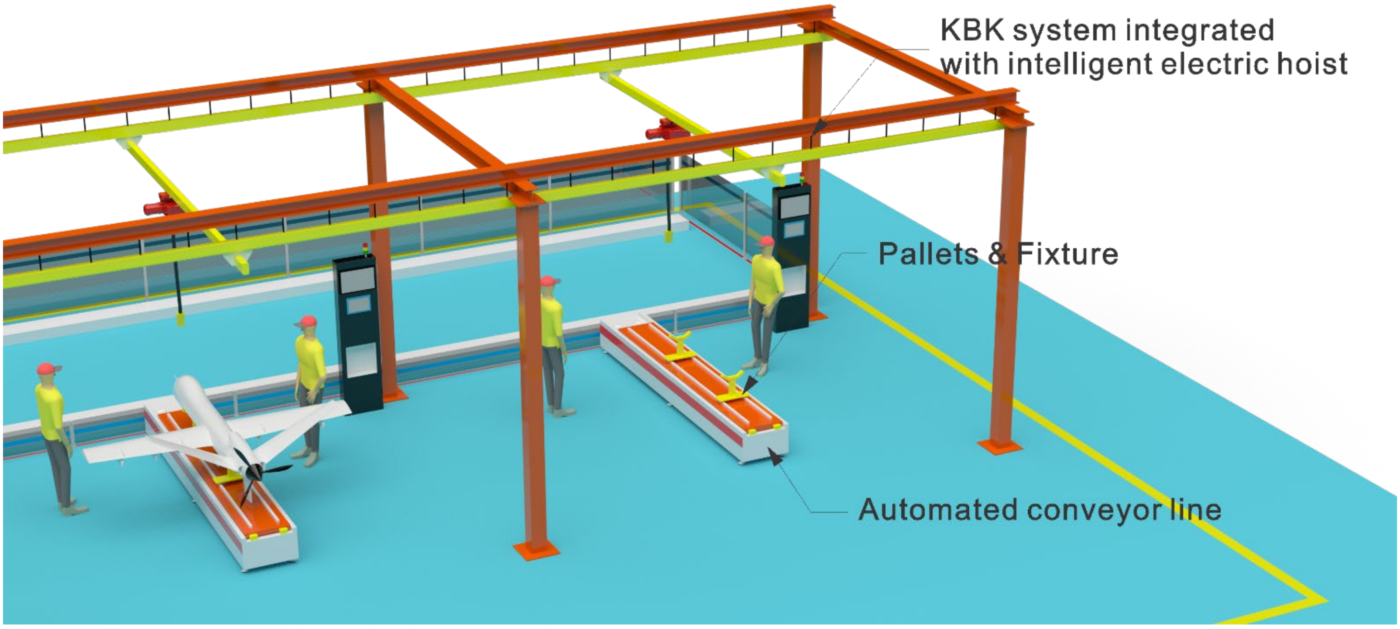
To accommodate the assembly of agricultural machinery of different sizes, the assembly line uses a Rail-Guided Vehicle (RGV) to connect and serve each operating station.



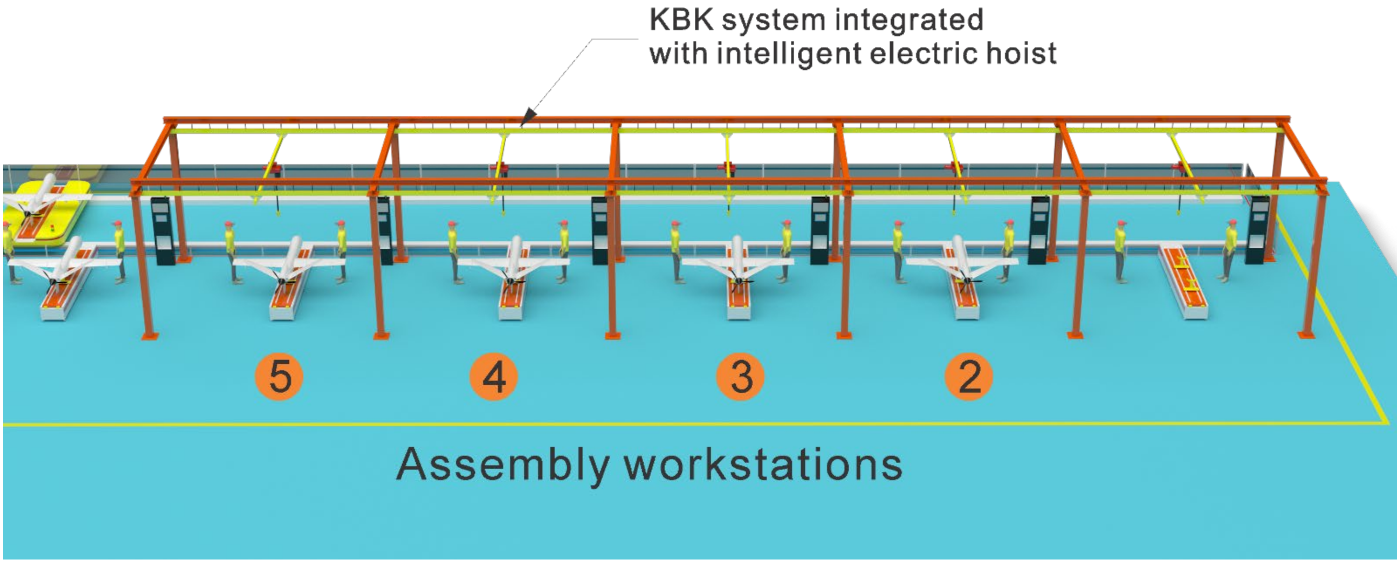
The RGV (Rail Guided Vehicle) adopts automated operation and high-precision travel positioning.



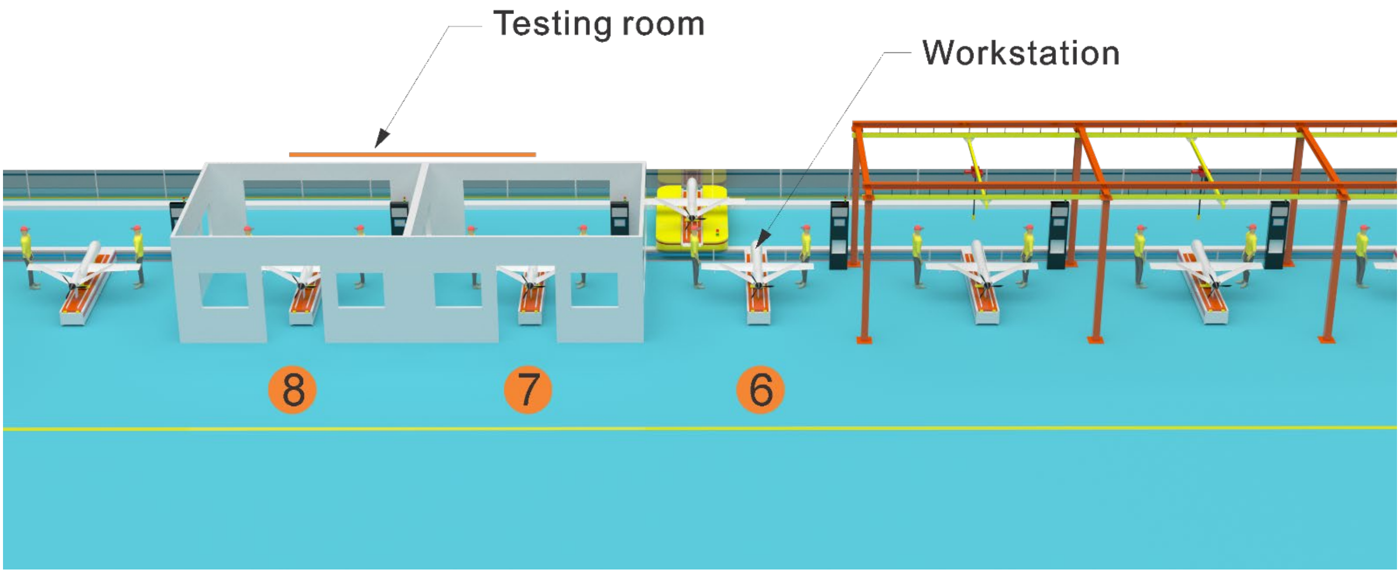
The first station of the assembly line is used for the loading of the products.



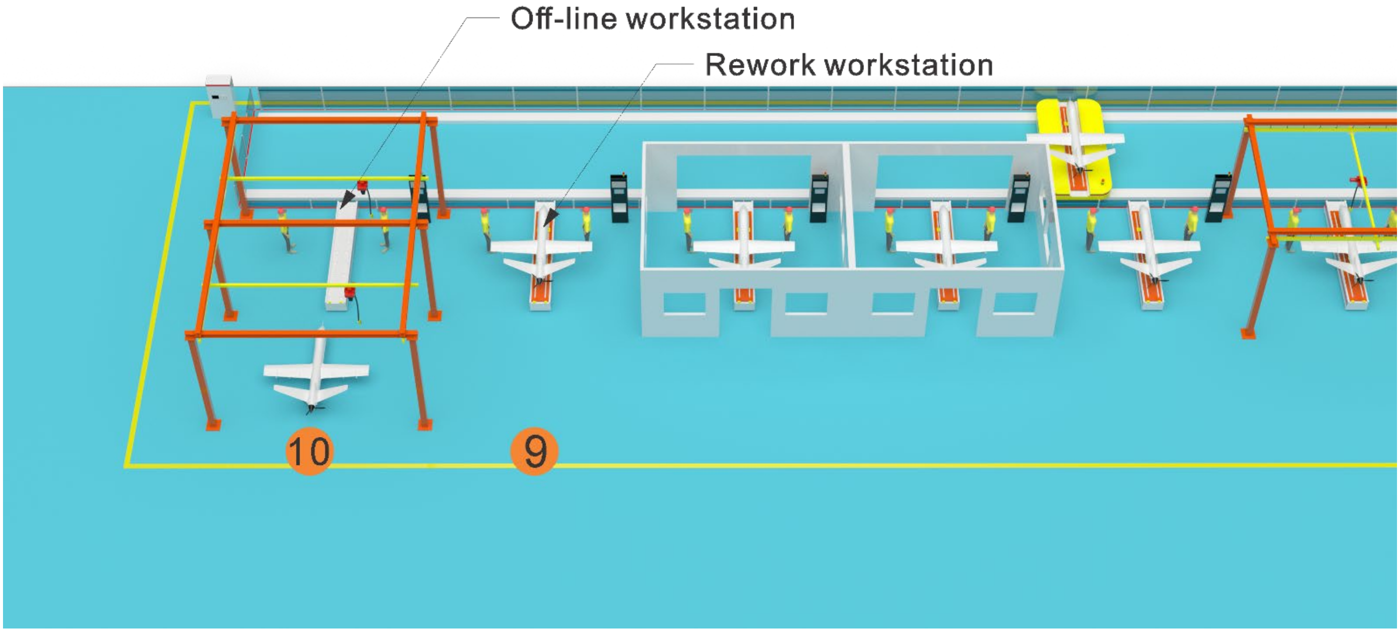
Each assembly station is equipped with a transfer line that connects to it, and the transfer lines operate automatically.



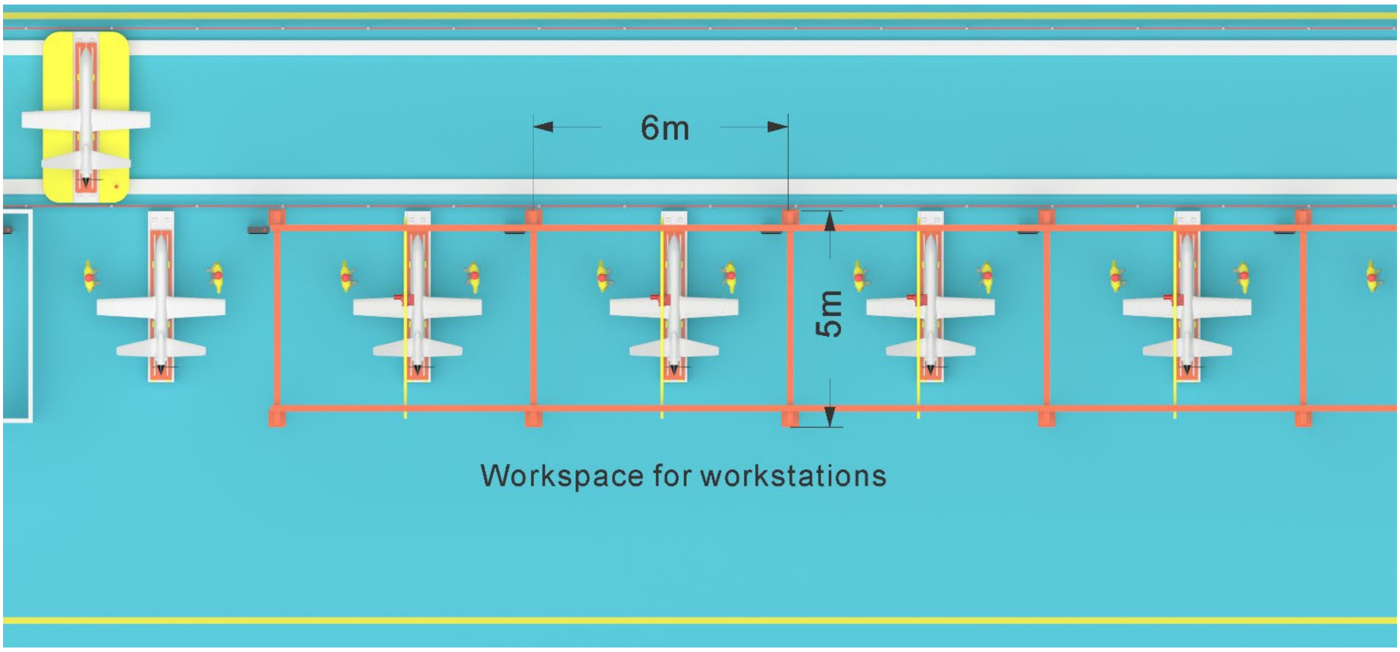
The assembly line is equipped with KBK rails and intelligent electric hoists at the top, which are used for the lifting and handling of workpieces.



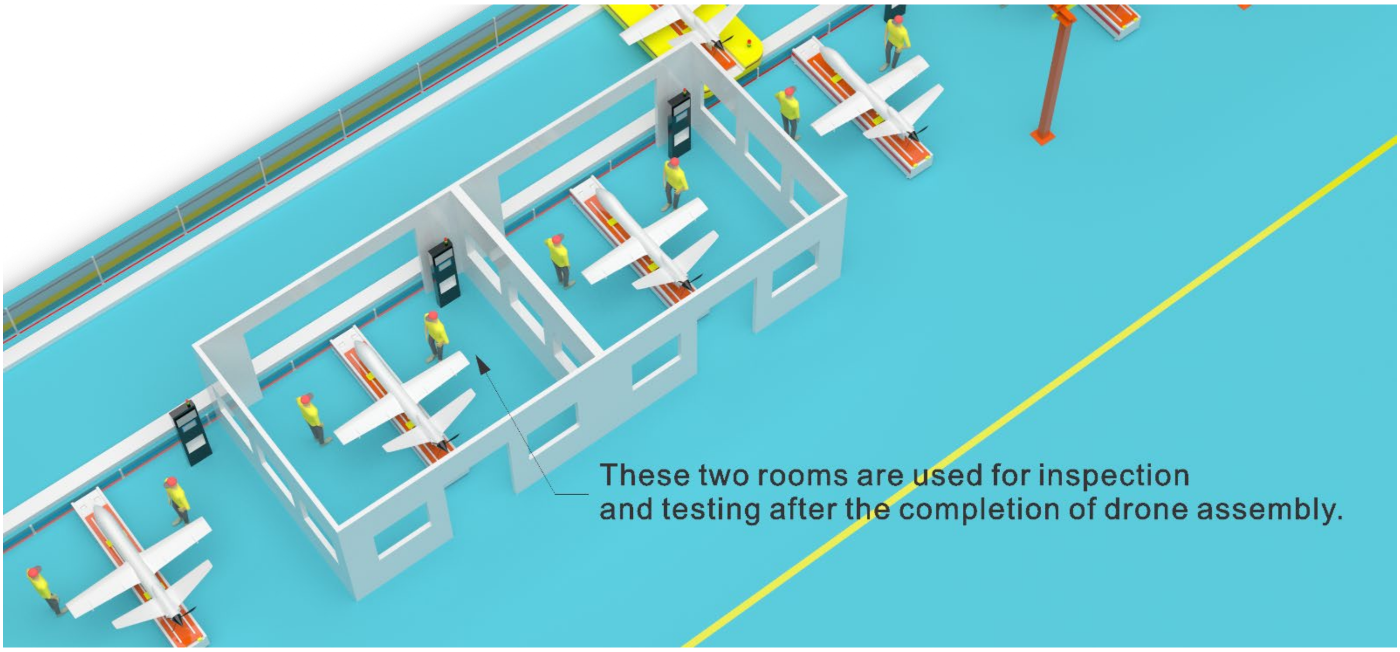
The assembly line is equipped with two testing stations, which are used for the performance testing of the assembled agricultural machinery.



The assembly line is equipped with a rework station, and the off-line process utilizes KBK hoisting for handling.

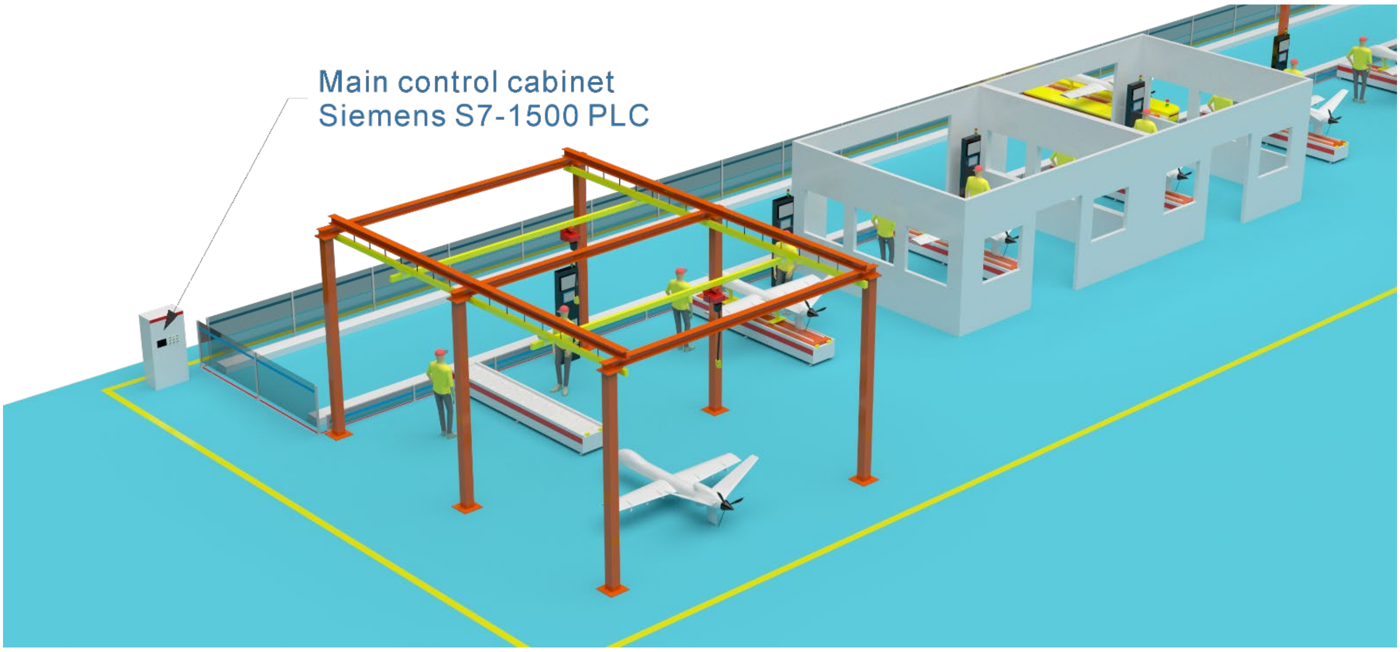


The reference dimensions for the operating station area are 6 meters by 6 meters.

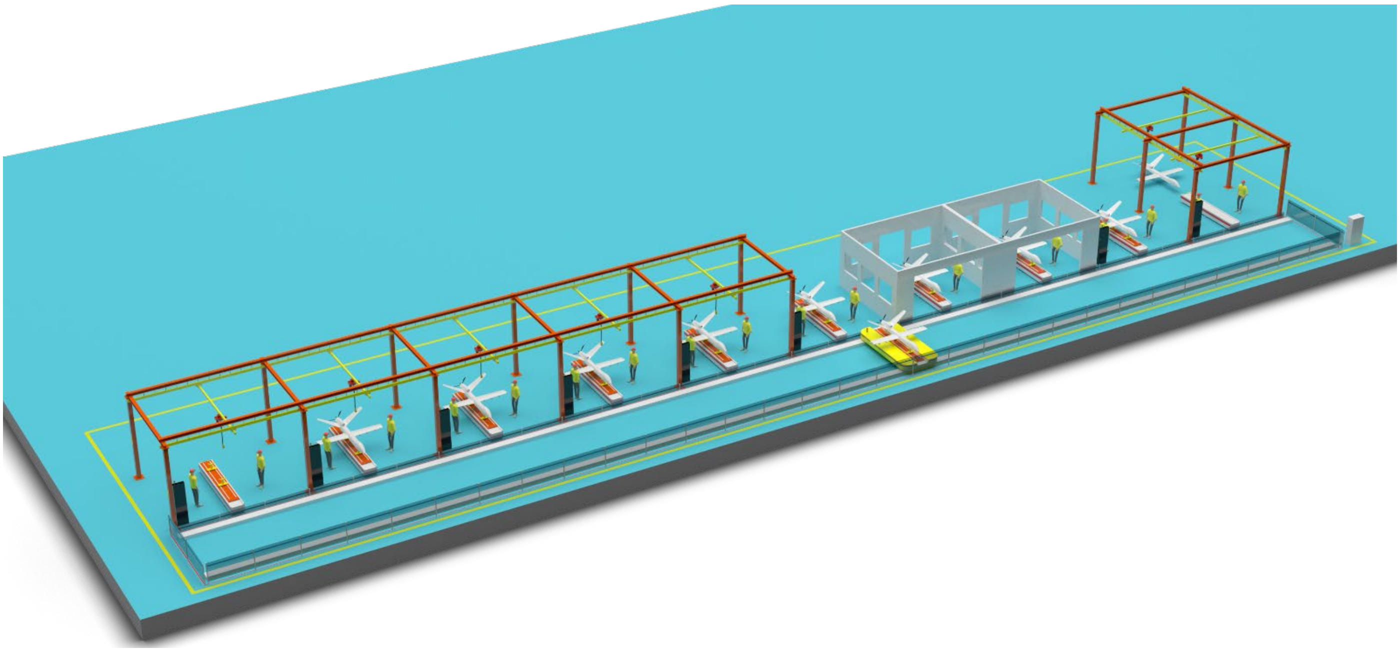


The two inspection stations are housed within isolated booths, which serve to provide protection and sound insulation.

Each operating station is integrated with a process display screen and a Siemens touch panel for control and communication.



The main control system of the assembly line uses the Siemens S7-1500 high-performance PLC.



The assembly line is designed with a modular approach, allowing for the expansion of workstations in the future based on production capacity requirements.

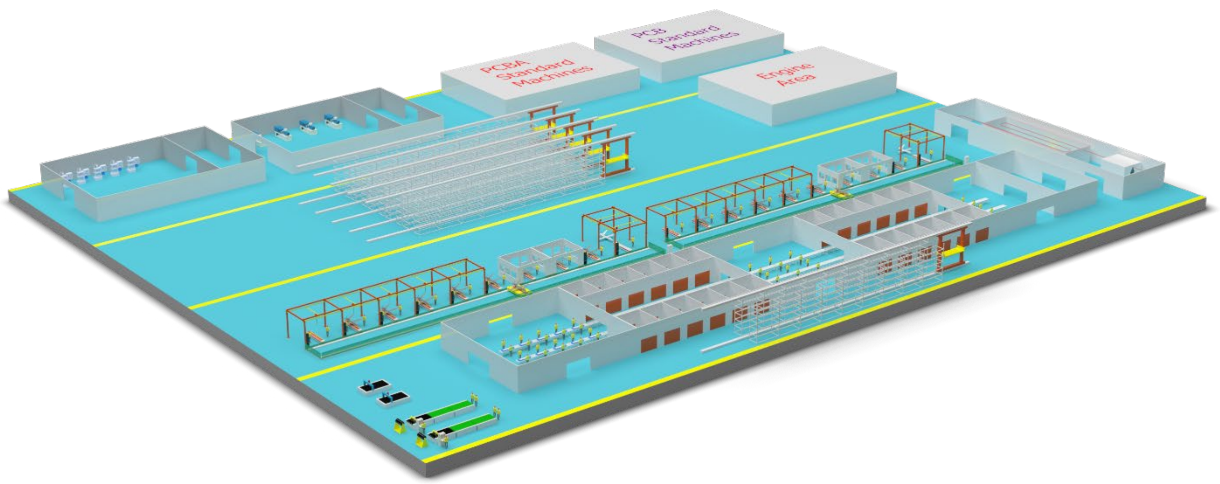
5. The factory, production workshop, and related support facilities

5.1. Factory Area

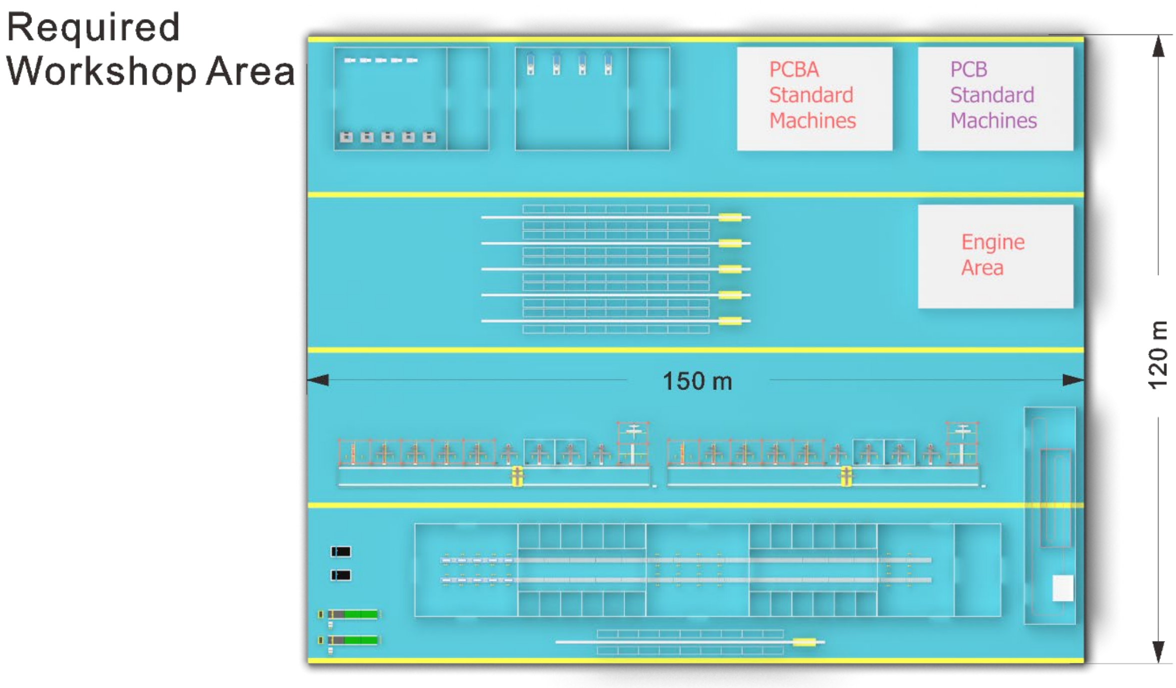
Functional Area	Location	Main Function	Components
Office Area	Near the main entrance or along the main road	Administrative management, client reception, meetings, etc.	Management offices, administrative offices, conference rooms, reception area, document room
Parking Lot	Adjacent to the office area	Providing parking for employees and visitors, facilitating vehicle access	Employee parking, visitor parking, truck parking
Power Distribution Facilities	Near the main entrance or production area	Providing and distributing electricity for the factory	Substation, distribution room, backup generator
Production Area	Core position of the factory	Actual manufacturing processes, including machining, assembly, welding, etc.	Production workshops, equipment installation area, production lines
Storage Area	Near the production area and loading/unloading zone	Storing raw materials, semi-finished products, and finished goods for quick turnover	Raw material warehouse, finished goods warehouse, semi-finished goods warehouse
Quality Inspection Area	Near the production area	Quality inspection and analysis of raw materials, semi-	Inspection room, laboratory, rework area

		finished products, and finished goods	
Logistics and Distribution Area	Near the storage area and loading/unloading zone	Loading/unloading, transportation, and logistics management of goods	Loading/unloading area, transport corridors, logistics office
Auxiliary Production Area	Distributed within the factory according to needs	Maintenance of production equipment, tool storage, and auxiliary power supply	Maintenance workshop, tool storage, air compressor station, boiler room, etc.
Employee Living Area	Located according to the scale and needs of the factory	Providing dining, accommodation, rest, and hygiene facilities for employees	Canteen, dormitories, changing rooms, showers, rest areas
Environmental and Safety Area	Distributed within the factory according to needs	Wastewater treatment, waste disposal, and fire safety measures	Wastewater treatment facilities, waste disposal area, fire safety equipment

5.2. Workshop

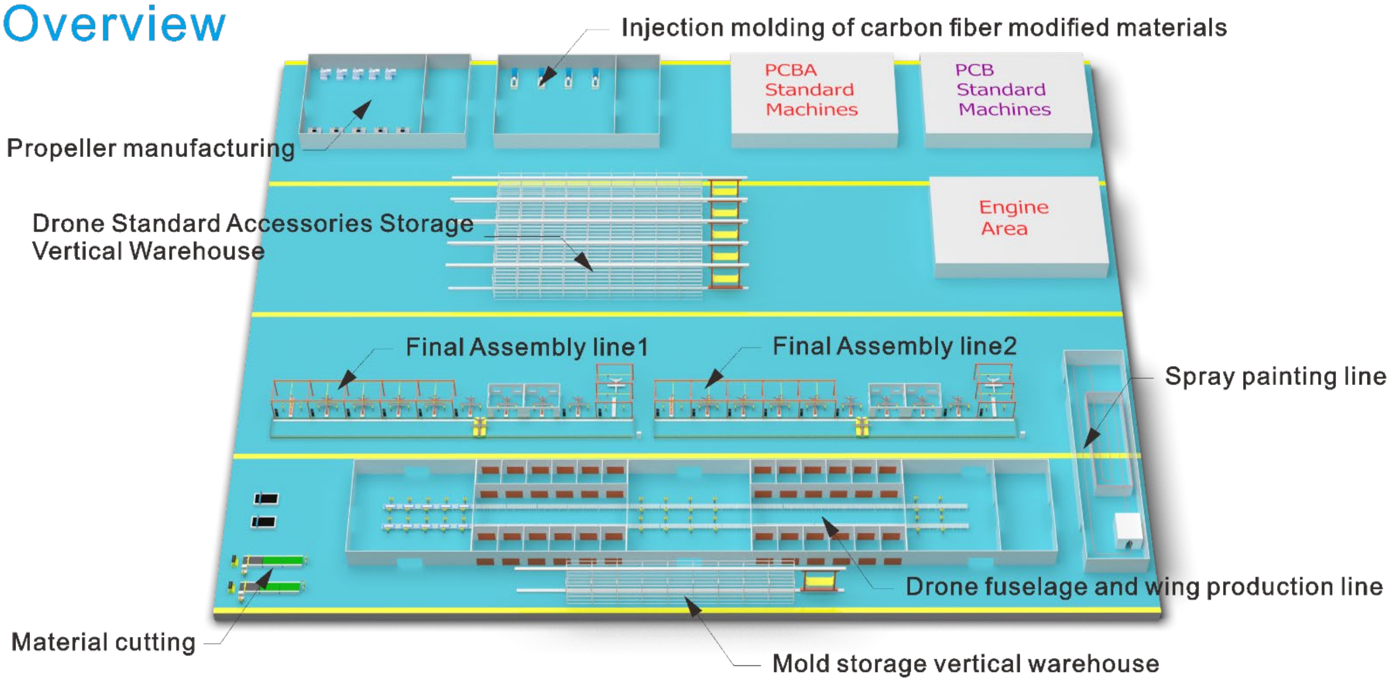


The production workshop is designed with a modern steel structure building, integrating component manufacturing and final assembly.



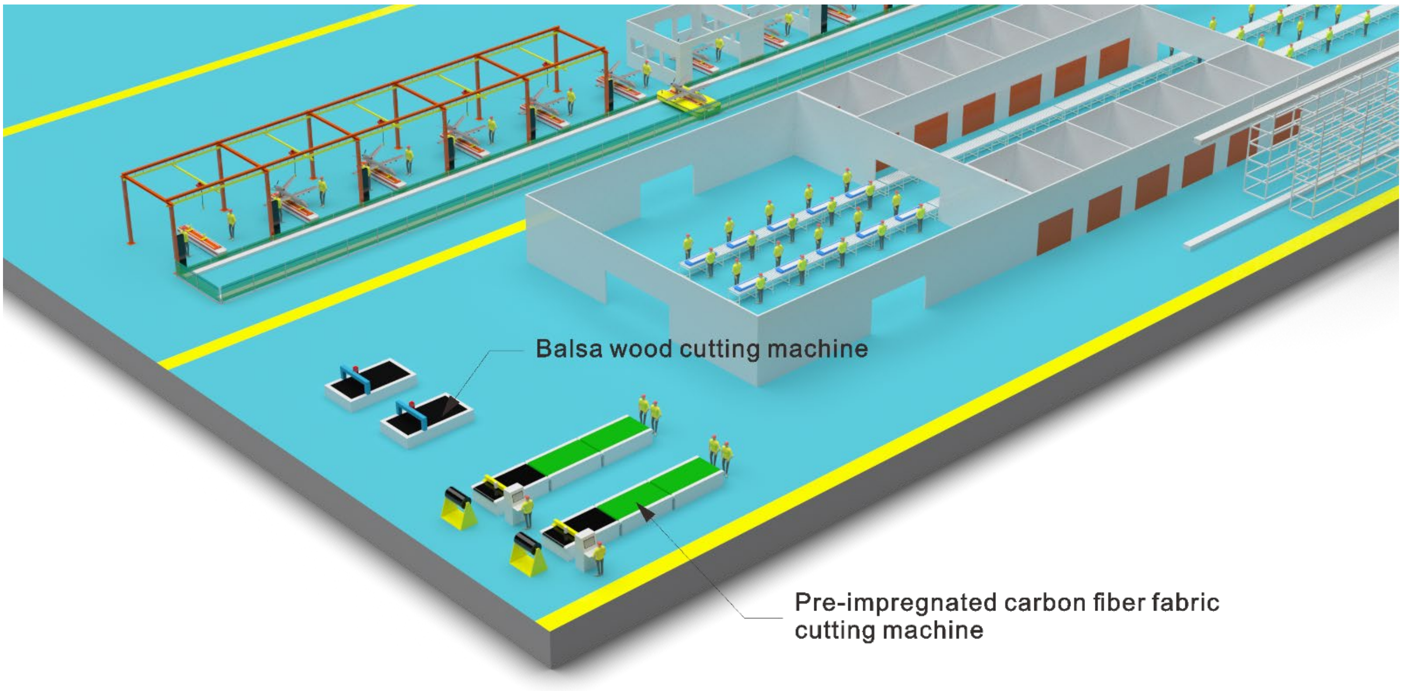
The estimated size of the workshop area is 150 meters in length, 120 meters in width, and the height is greater than 10 meters.

Overview

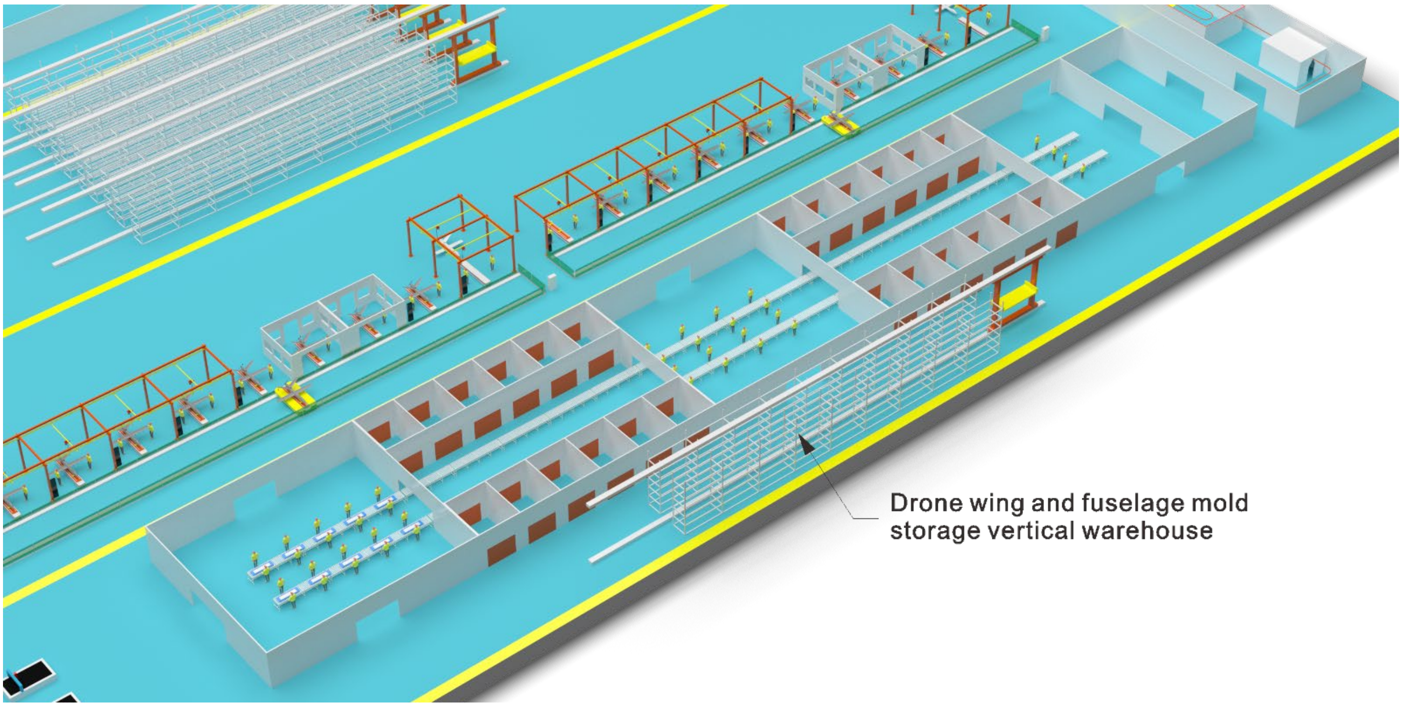


Workshop Manufacturing				
Workshop for Manufacturing Drone Fuselages and Wings	150 meters by 30 meters	150 meters by 120 meters（Can be integrated into a single workshop）	40 sets (8-hour)	40 sets (8-hour) per day 800 sets (20-day) per month
Painting Workshop	50 meters by 15 meters		80 sets (8-hour)	
Propeller Manufacturing Workshop	40 meters by 30 meters		40 sets (8-hour)	
Injection Molding Workshop for PPA Carbon Fiber Modified Materials and Plastic	40 meters by 30 meters		100 sets (8-hour)	
PCB Manufacturing Workshop	40 meters by 30 meters		100 sets (8-hour)	
PCBA SMT (Surface-Mount Technology) Assembly Manufacturing Workshop	40 meters by 30 meters		100 sets (8-hour)	
Engine Assembly Workshop	40 meters by 30 meters		50 sets (8-hour)	

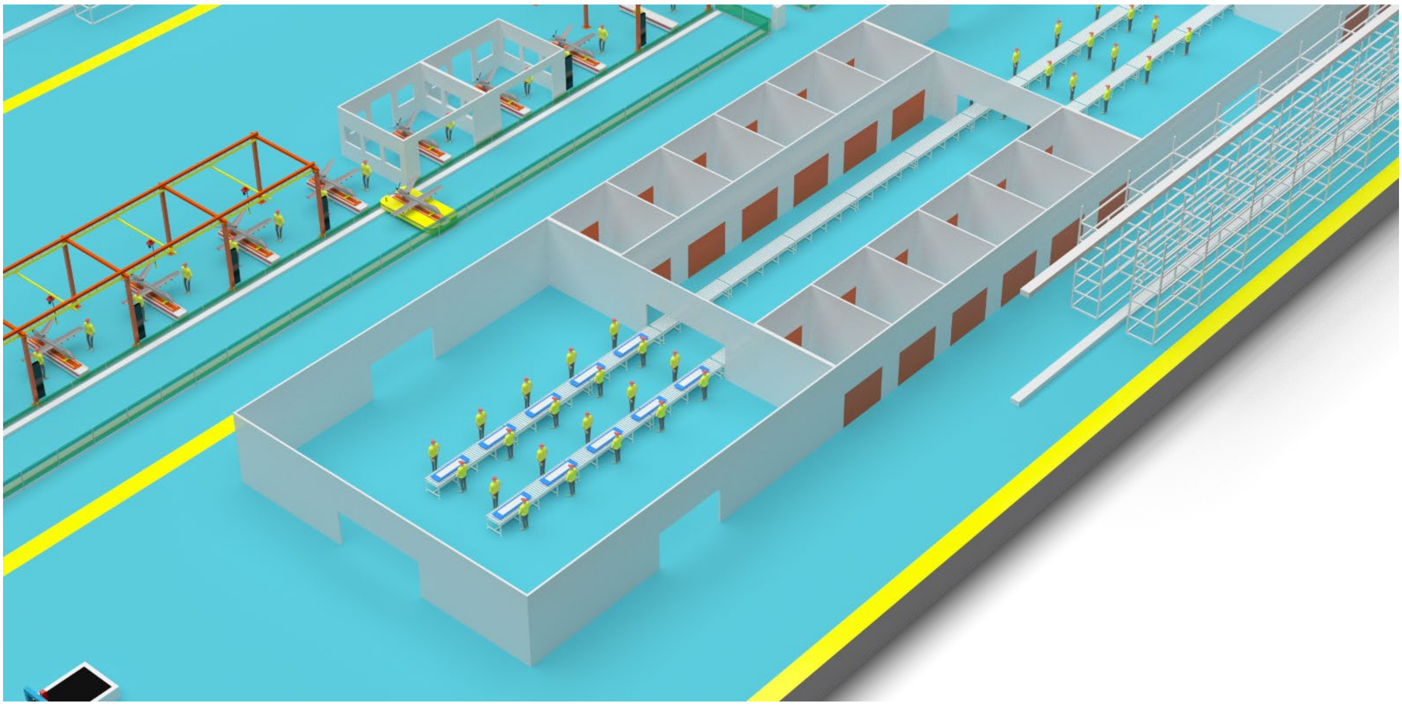
Final Assembly Workshop	150 meters by 30 meters		50 sets (8-hour)	
Workshop for Automated Stereoscopic Warehouse	60 meters by 30 meters			
Supporting facilities: electrical distribution room, air compressor room, vacuum pump room, generator set, cold storage for carbon fiber prepreg, etc.				



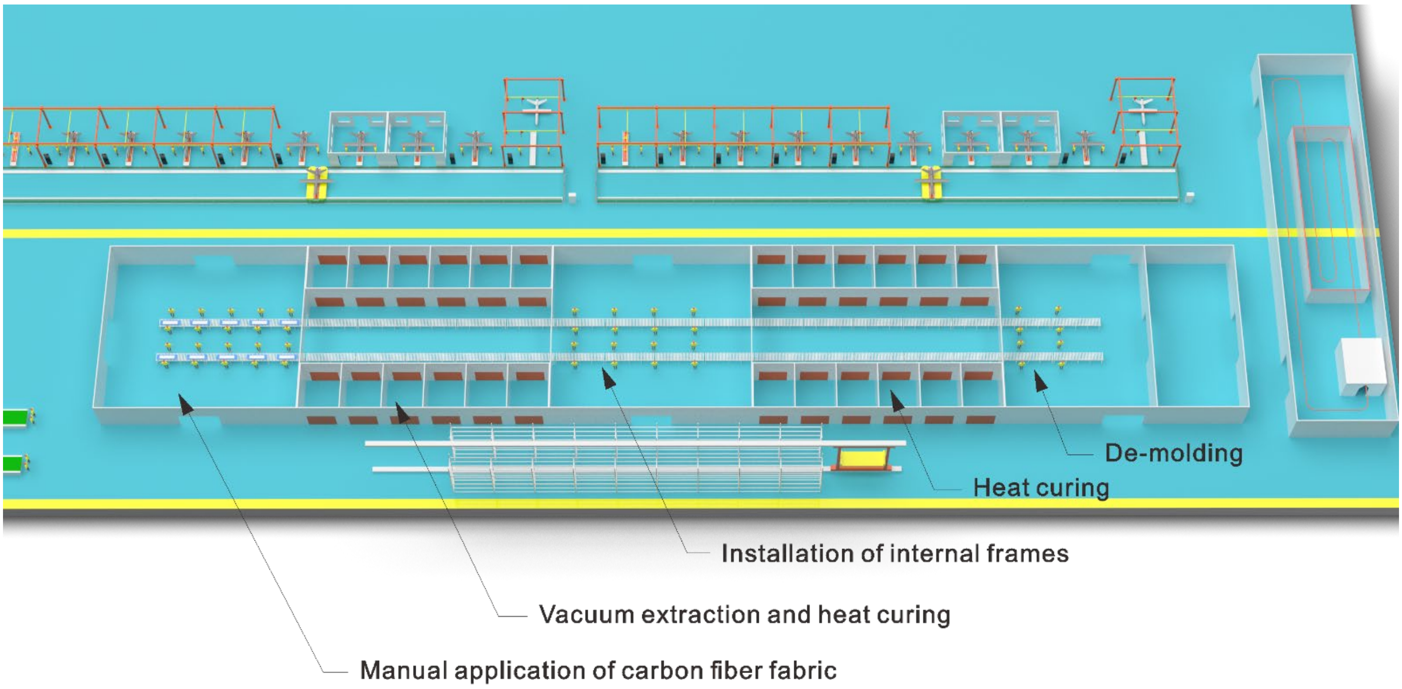
Balsa wood laser cutting and vibration knife cutting of prepreg carbon fiber.



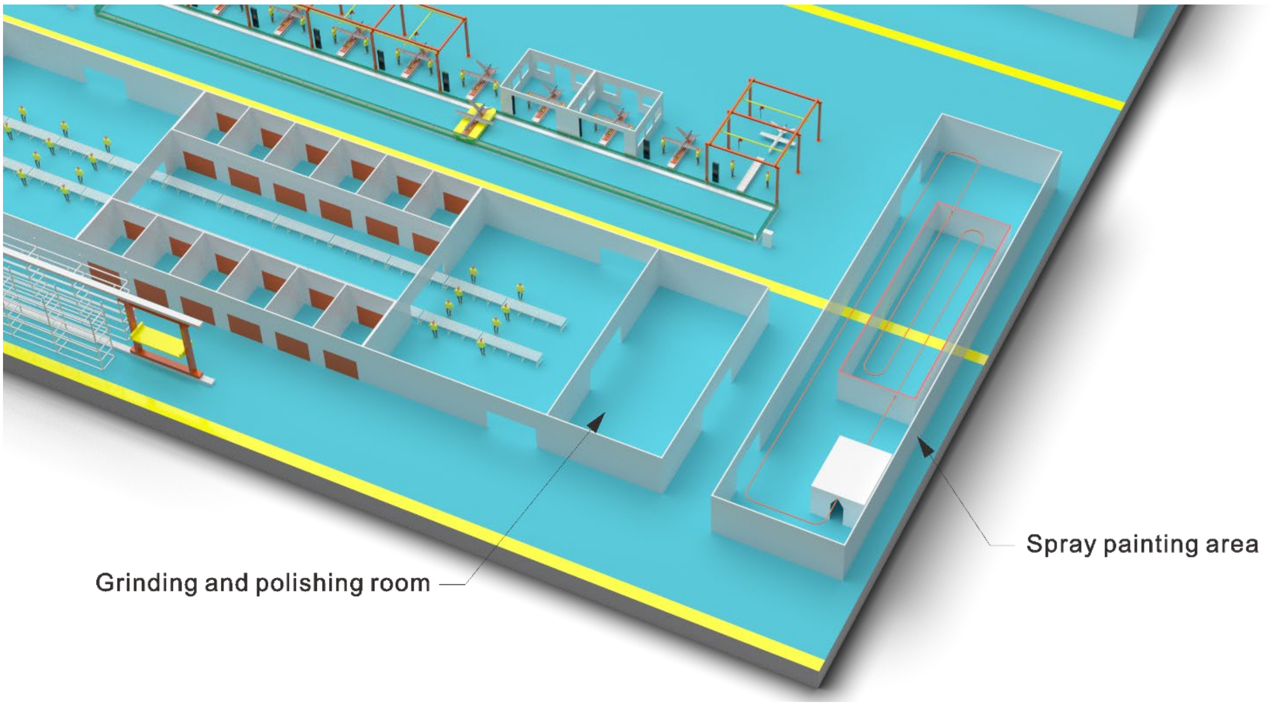
There are a large number of molds for carbon fiber composite material casings, which require storage in a high-bay warehouse to facilitate categorized storage and management.



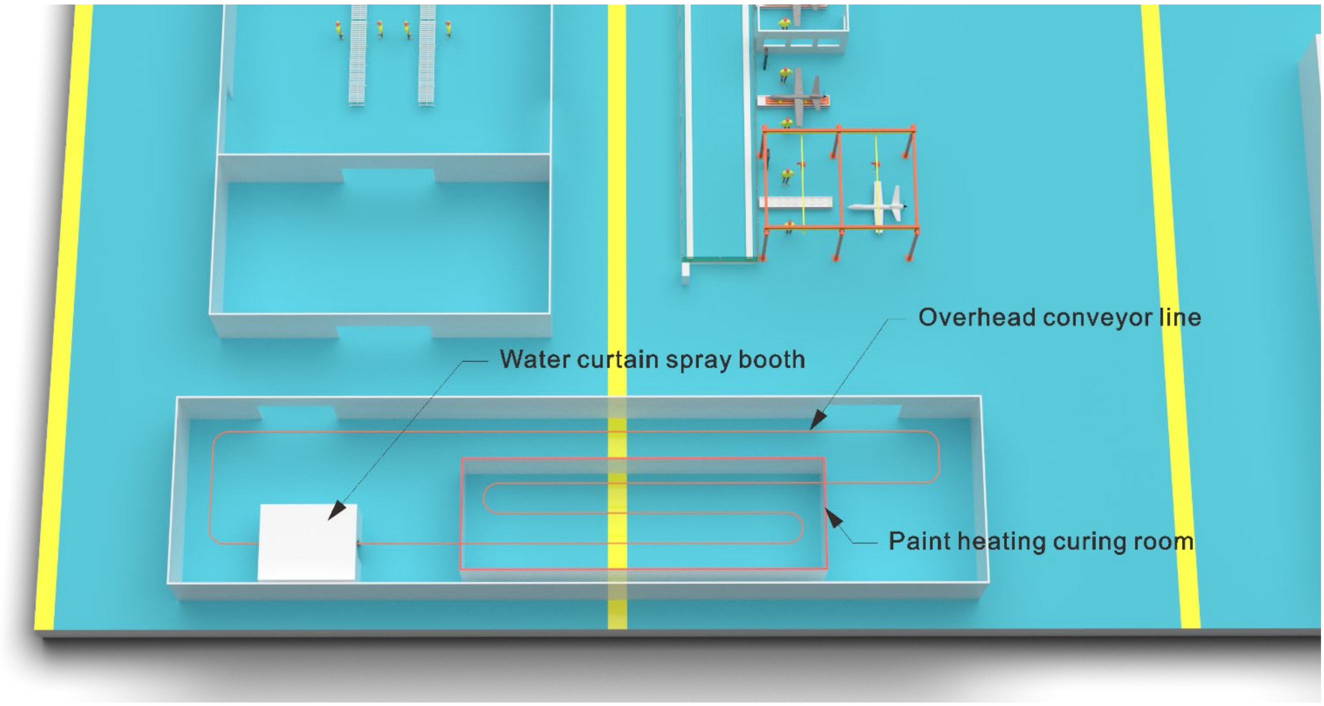
The workshop for processing carbon fiber composite workpieces features an automated conveying line combined with manual operation.



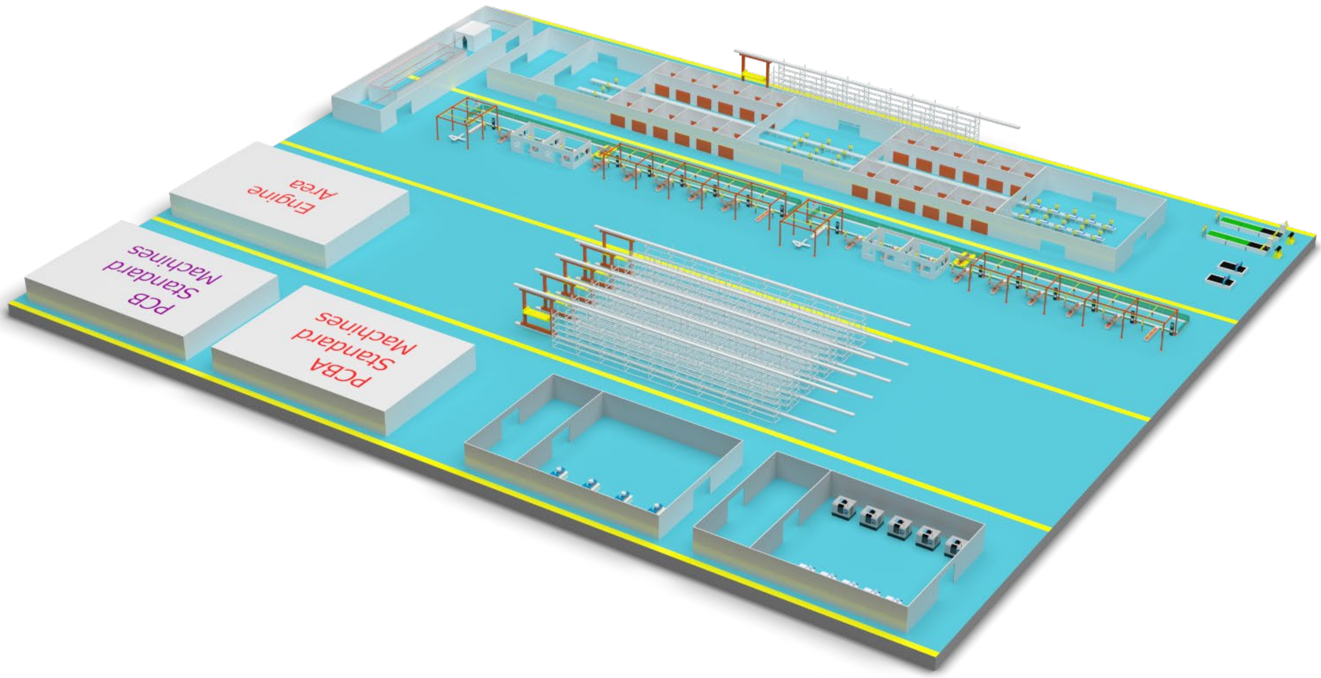
The processing of carbon fiber composite structural components is carried out step by step in accordance with the process flow.



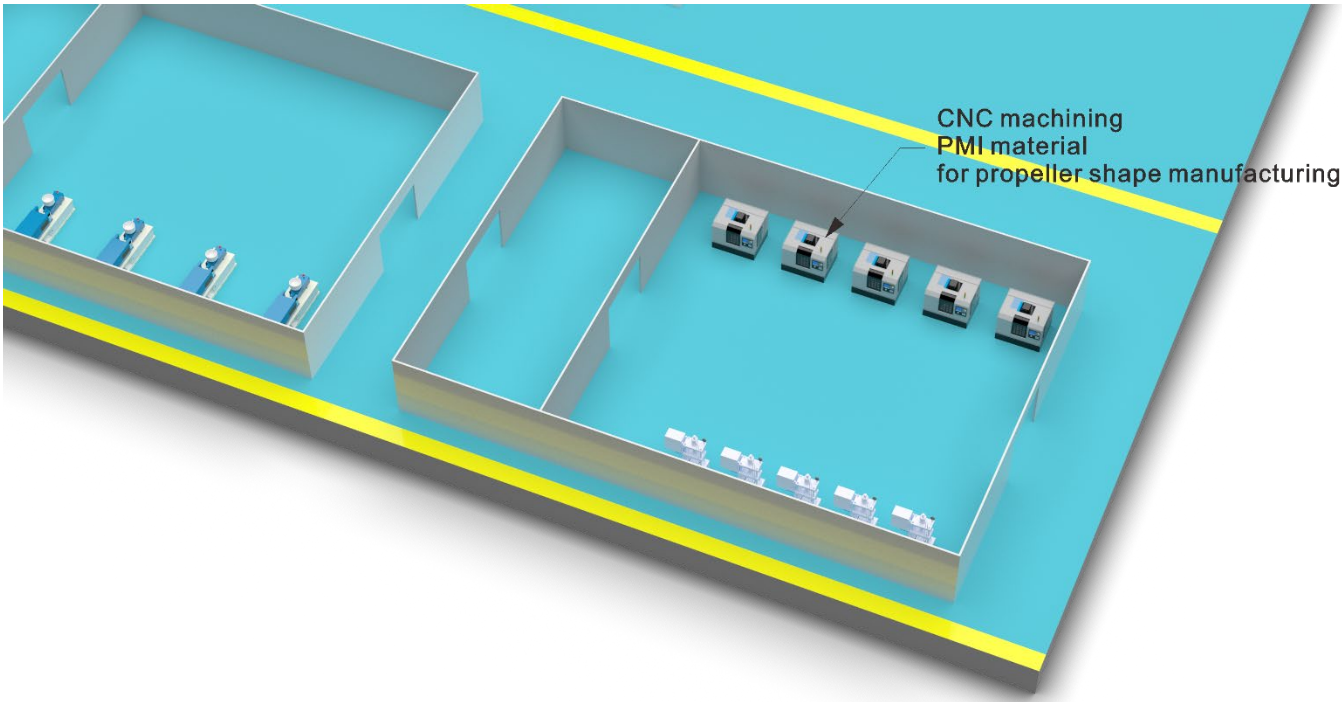
After processing, carbon fiber composite components require surface grinding and finishing to achieve a smooth and defect-free surface.



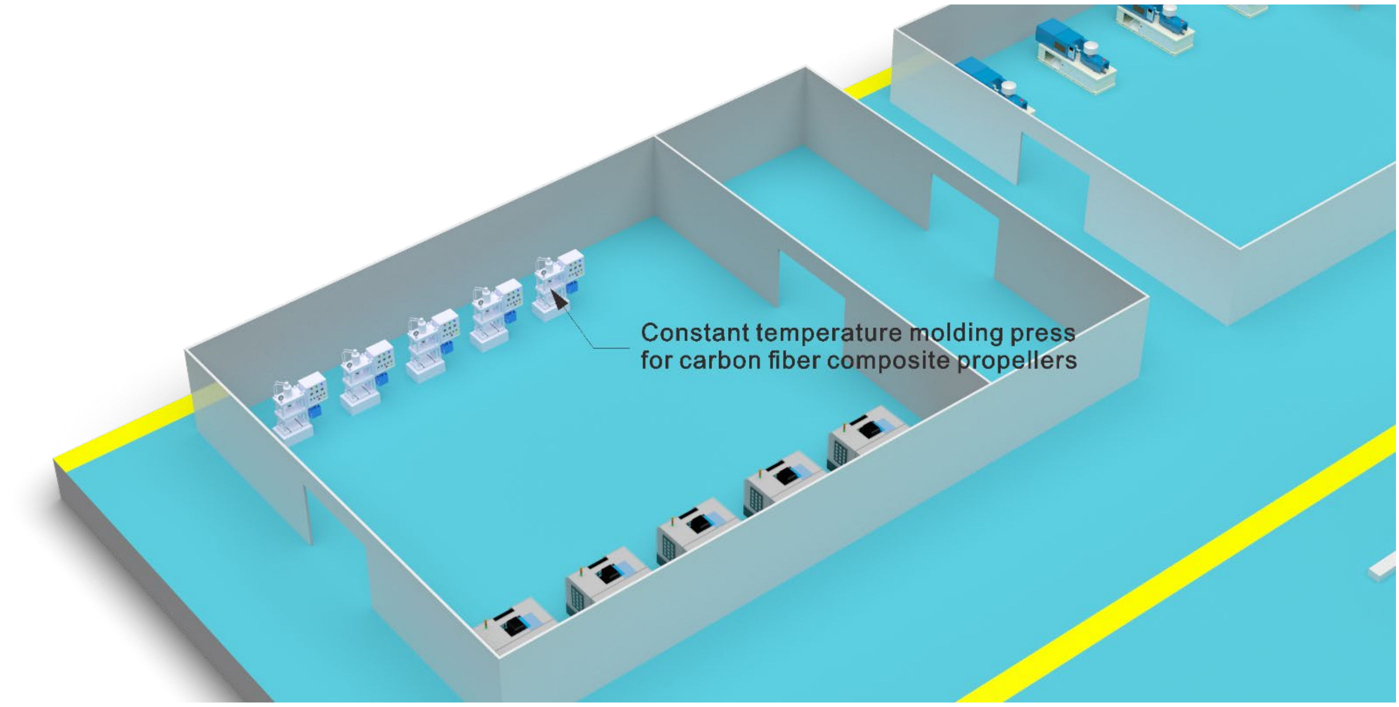
Surface painting treatment, involving one or multiple layers of surface painting, followed by polishing after painting.



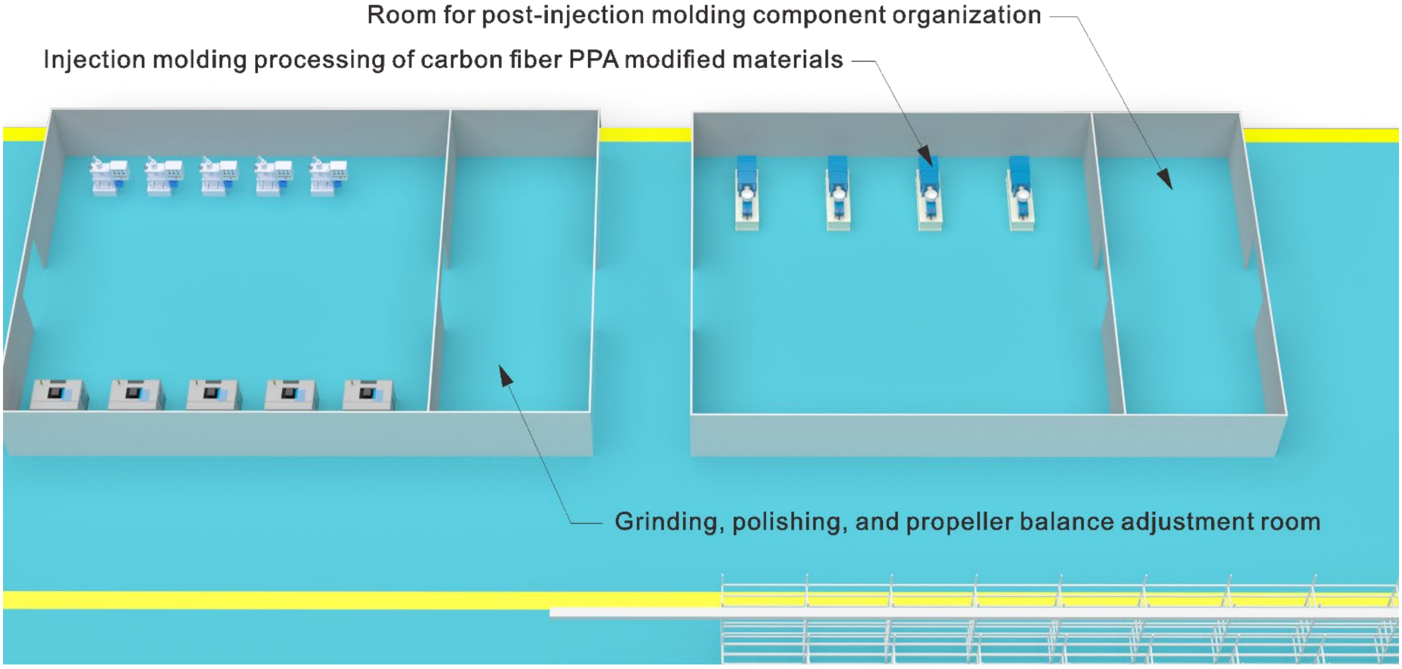
Component machining workshop area



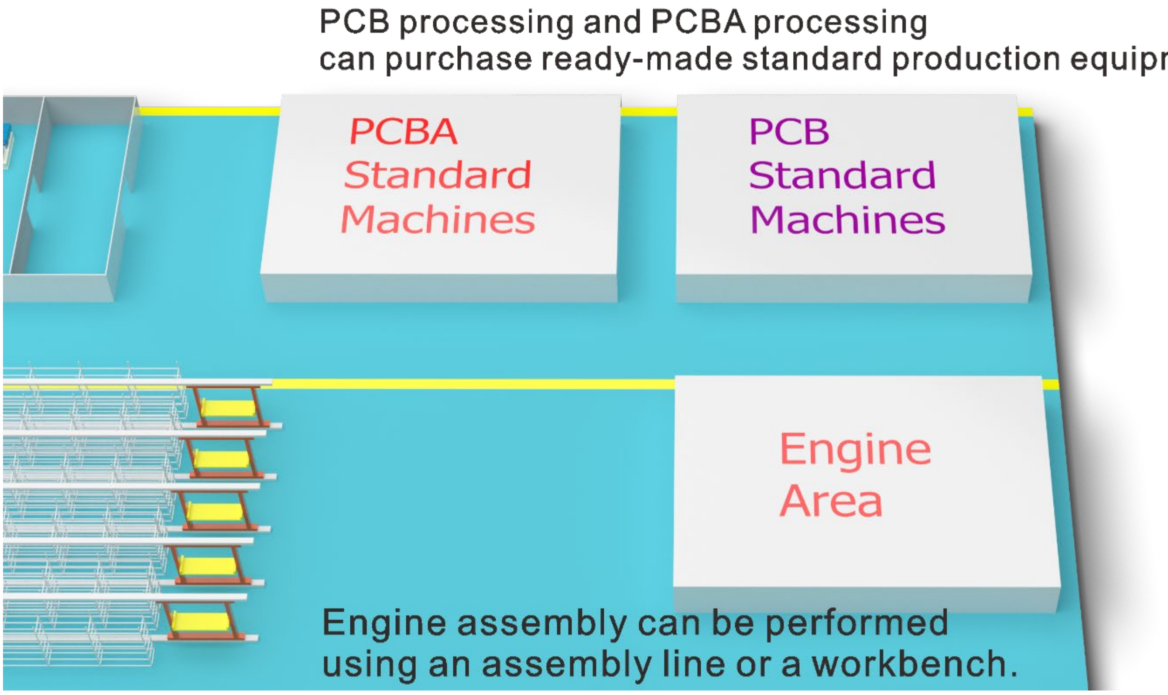
CNC machining of PMI foam material (after foaming).



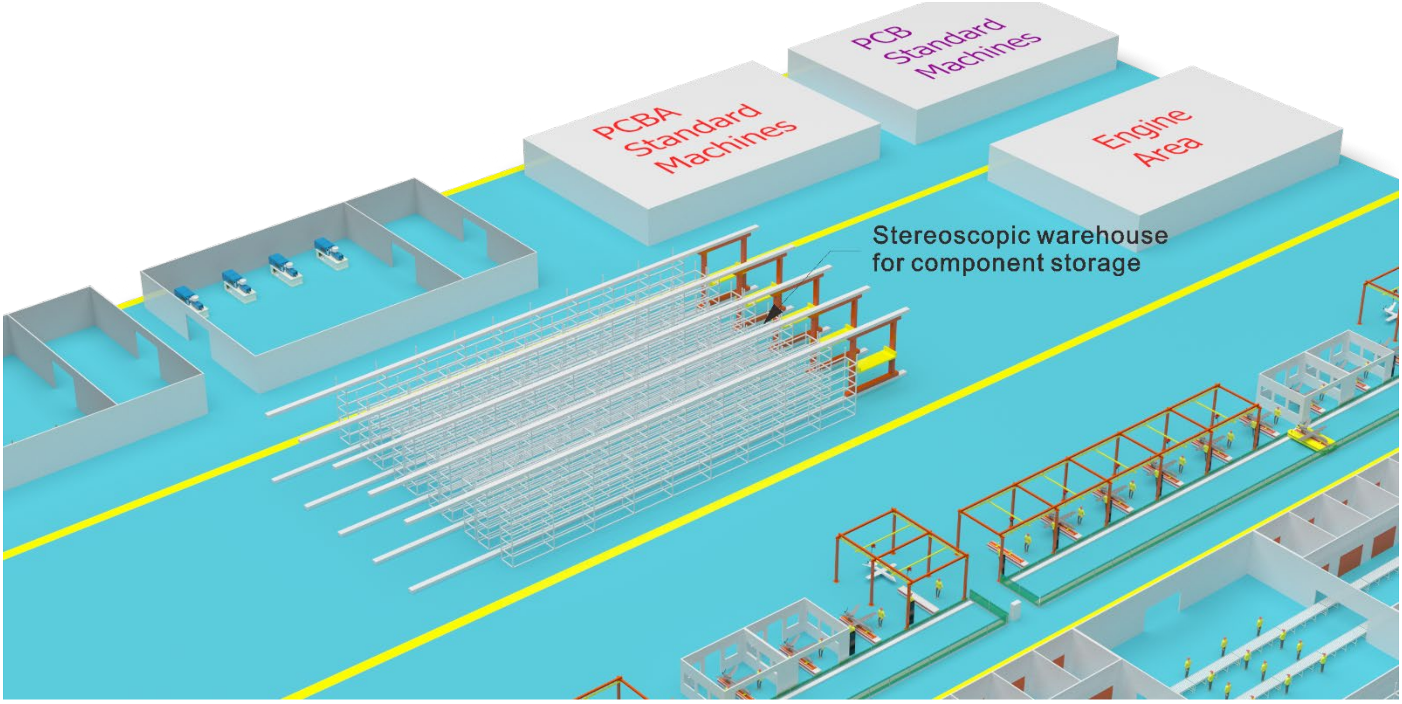
Hot-press molding, surface treatment, and balance adjustment of carbon fiber composite propellers.



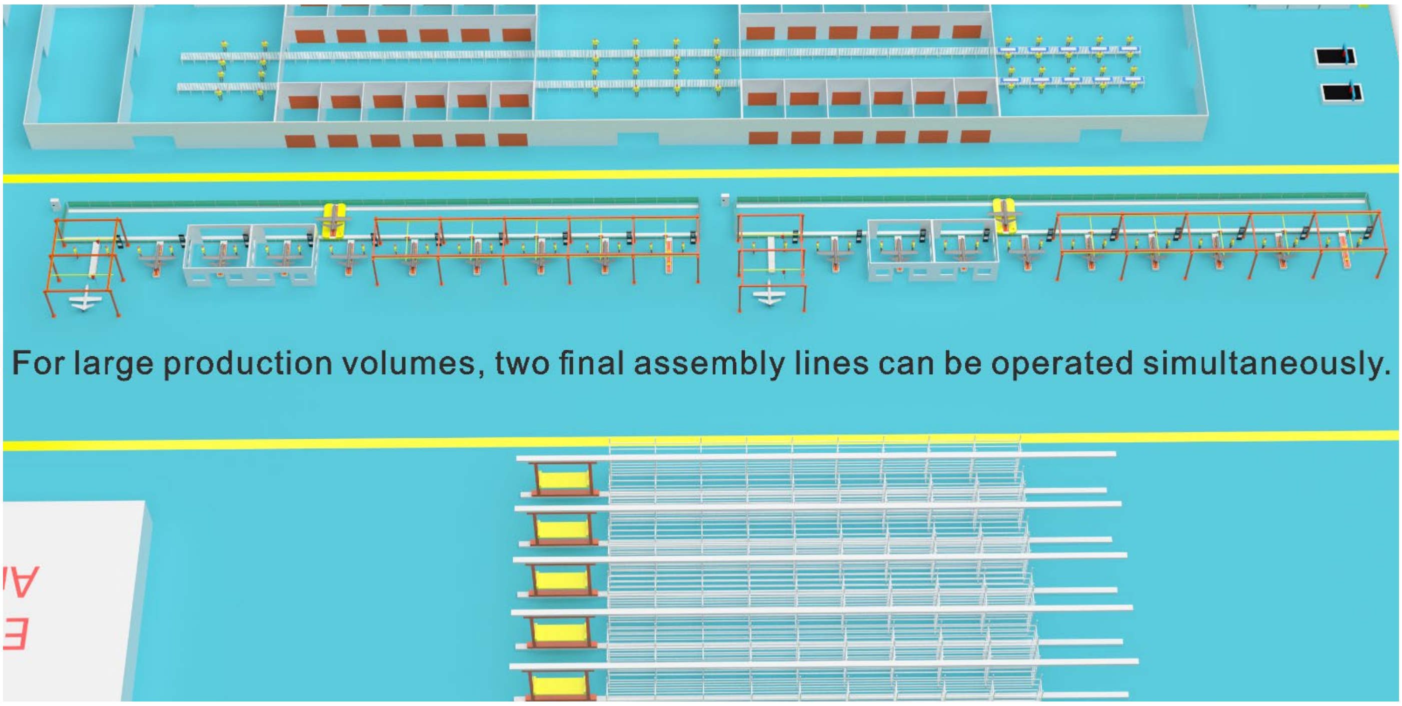
Injection molding of carbon fiber-reinforced materials, such as internal supports.



PCB and PCBA production workshops, engine assembly and testing workshops.

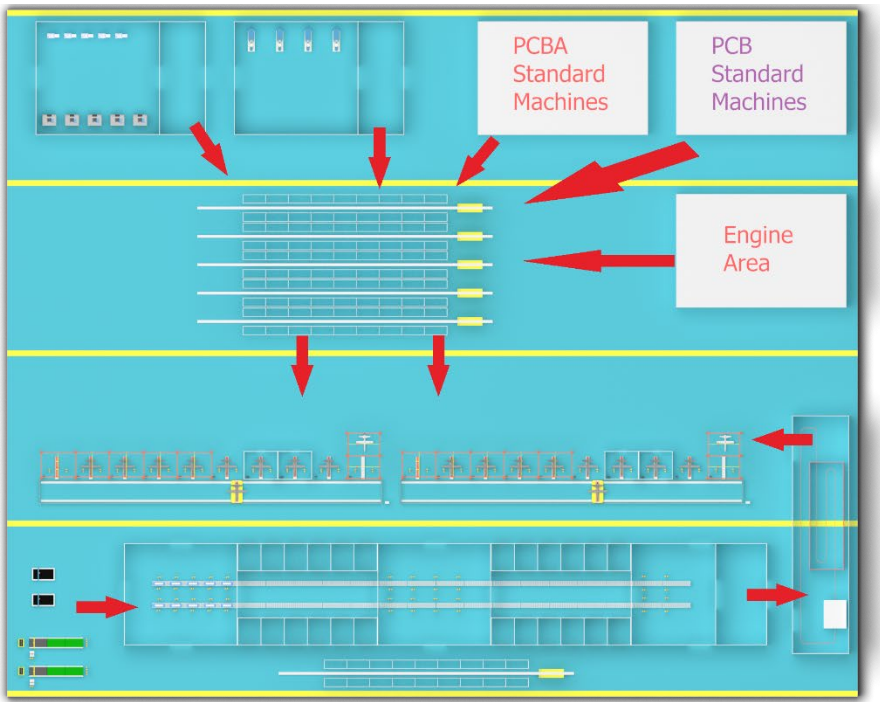


A three-dimensional warehouse within the workshop, used for the storage and management of purchased components and in-house manufactured parts.

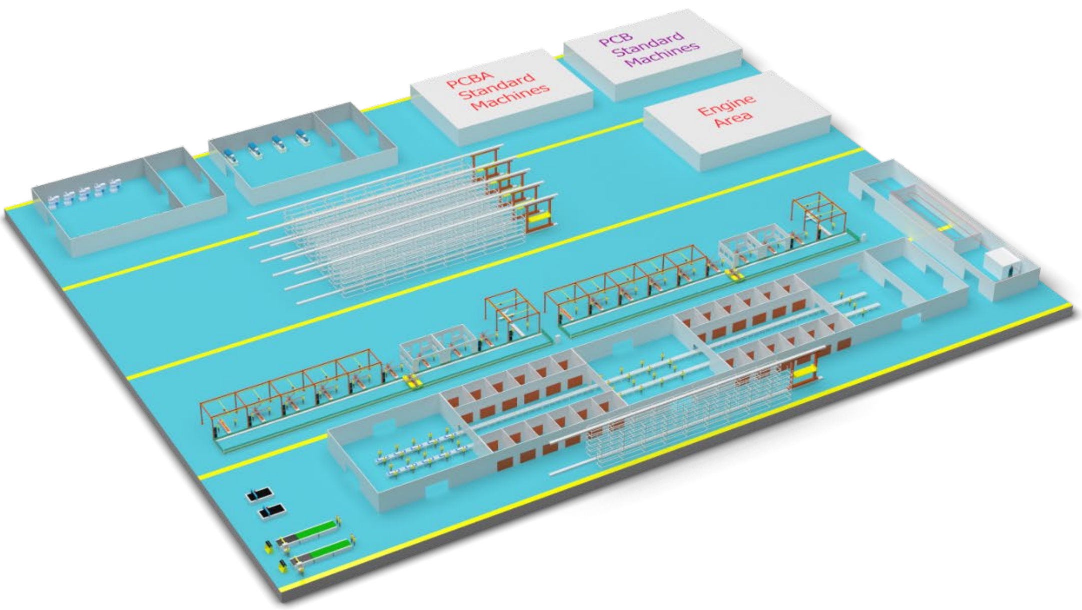


The final assembly production line is divided into two sets, capable of assembling different models of agricultural machinery simultaneously.

Internal Logistics



Smooth workshop logistics contribute to more efficient production management and the ability to meet order demands.



Depending on production needs, it is also possible to divide the workshop into separate sections for different production functions.

The production workshop also needs to consider the configuration of power supply, compressed air supply, water supply, fire protection facilities, temperature and humidity control, lighting, and other such arrangements.

6. Equipment Operation Training

6.1. Equipment Operation Technical Training

No.	Training Content	Training Objectives	Training Methods
1	Operation Procedures and Standards	Master the basic procedures for starting, operating, and stopping equipment to ensure safe operation.	Theoretical lecture + Practical demonstration
2	Equipment Functions and Parameter Settings	Understand the various functions of the equipment and learn how to adjust parameters to meet production requirements.	Theoretical lecture + Practical exercises
3	Operation Skills Training	Improve operational proficiency and develop the ability to observe and judge the equipment's operating status.	Simulation + Actual operation practice

6.2. Equipment Maintenance Technical Training

No.	Training Content	Training Objectives	Training Methods
1	Daily Maintenance	Learn how to clean, lubricate, and inspect equipment, and master the content of daily inspections.	Theoretical lecture + On-site practice
2	Periodic Maintenance	Understand the periodic maintenance plan for equipment, and learn how to	Theoretical lecture + Practical exercises

		replace consumable parts and check performance indicators.	
3	Preventive Maintenance	Learn preventive measures for equipment failures and how to develop a preventive maintenance plan.	Case analysis + Theoretical lecture

6.3. Equipment Repair Technical Training

No.	Training Content	Training Objectives	Training Methods
1	Fault Diagnosis	Learn to identify and analyze equipment failures and master the skills for judging faults.	Case analysis + Practical exercises
2	Repair Skills	Master the use of repair tools and learn how to replace, repair, and adjust parts.	Theoretical lecture + Practical exercises
3	Repair Management	Learn how to develop a repair plan and master the methods for recording and managing repairs.	Theoretical lecture + Case analysis

6.4. Training Summary and Assessment

No.	Content	Description
1	Training Summary	Review the training content and summarize key points and difficulties.
2	Assessment Methods	Written test (40%) + Practical assessment (60%)

3	Pass Criteria	Written test ≥ 60 points, Practical assessment ≥ 70 points. Both must be passed to complete the training.

6.5. Training Schedule (The time required varies depending on the device. The following is for reference only)

Training Module	Time Arrangement	Notes
Equipment Operation Technical Training	Day 1 (Morning, Afternoon)	Theoretical lecture + Practical exercises
Equipment Maintenance Technical Training	Day 2 (Morning, Afternoon)	Theoretical lecture + Practical exercises
Equipment Repair Technical Training	Day 3 (Morning, Afternoon)	Theoretical lecture + Practical exercises
Training Summary and Assessment	Day 4 (Morning)	Summary, Written test + Practical assessment

6.6. Training Resource Requirements (The time required varies depending on the device. The following is for reference only)

Resource Type	Specific Content	Quantity
Training Instructors	Experts in equipment operation, maintenance, and repair	2-person
Training Venue	Theoretical classroom, equipment operation room	1 theoretical classroom, 1 equipment operation room
Training Equipment	Equipment for training, repair tools	1 set of equipment, 1 set of repair tools
Training Materials	Training manuals, operation guides, assessment papers	Several copies

7. Technical Requirements and Engineer Profiles for the Design and Manufacturing of Lightweight Intelligent Agricultural Machinery

7.1. Intelligent Agricultural Machinery System Design Engineer

Responsibilities:

- Conduct top-level requirement analysis, system design, and subsystem performance allocation for intelligent agricultural machinery.
- Develop and validate system-level test environments.
- Coordinate with subsystem engineers to ensure overall design meets performance requirements.

Skill Requirements:

- Familiar with the overall design methods of intelligent agricultural machinery, including fixed, mobile, and hybrid types.
- Proficient in systems engineering knowledge, and familiar with subsystems such as mechanical, electrical, control, and power systems.
- Skilled in using design software such as CATIA and Solidworks.
- Knowledgeable about the six major design aspects of agricultural machinery (reliability, maintainability, testability, supportability, safety, and environmental adaptability).
- Strong communication and teamwork skills.

7.2. Intelligent Agricultural Machinery Structural Design Engineer

Responsibilities:

- Responsible for structural design and optimization of intelligent agricultural machinery, including strength analysis, material selection, and manufacturing process coordination.
- Participate in structural component testing and validation to ensure design requirements are

met.

Skill Requirements:

- Proficient in at least one 3D modeling software, such as Solidworks or CATIA.
- Familiar with common engineering materials and manufacturing processes, such as sheet metal, injection molding, and welding.
- Knowledgeable about structural finite element analysis software, such as ANSYS.
- Basic understanding of composite material properties and manufacturing processes.
- Strong hands-on and problem-solving abilities.

7.3. Intelligent Agricultural Machinery Aerodynamic Design Engineer

Responsibilities:

- Design the aerodynamic layout and conduct aerodynamic performance simulations for intelligent agricultural machinery.
- Develop dynamic modeling and performance evaluation for flight mechanics (for aerial agricultural machinery).
- Support wind tunnel and flight tests to optimize aerodynamic performance.

Skill Requirements:

- Proficient in aerodynamics and flight mechanics knowledge.
- Skilled in using software for 3D surface design and aerodynamic simulation (such as Fluent, XFOIL).
- Experience in designing new layouts for agricultural machinery is preferred.
- Familiar with wind tunnel testing procedures and data analysis methods.

7.4. Intelligent Agricultural Machinery Control System Design Engineer

Responsibilities:

- Design, develop, debug, and optimize control systems for intelligent agricultural machinery.
- Implement and test control algorithms to ensure stable and safe operation of the machinery.

Skill Requirements:

- Proficient in digital circuit design, analog circuit design, and microcontroller principles.
- Skilled in programming languages such as C, and familiar with PCB design tools (such as Altium Designer).
- Knowledgeable about mainstream control systems (such as PLCs, microcontrollers) and capable of debugging control parameters.
- Familiar with control theory, including PID control and adaptive control.

7.5. Intelligent Agricultural Machinery Hardware Engineer

Responsibilities:

- Design hardware solutions for intelligent agricultural machinery, including schematic design and PCB layout.
- Debug and optimize hardware to ensure performance requirements are met.

Skill Requirements:

- Proficient in hardware design and development processes, with strong debugging capabilities.
- Knowledgeable about common baseband and RF hardware design.
- Skilled in using test equipment such as vector network analyzers, spectrum analyzers, and oscilloscopes.
- Familiar with embedded system development and capable of hardware selection and integration.

7.6. Intelligent Agricultural Machinery Embedded Software Engineer

Responsibilities:

- Develop, debug, and optimize embedded systems for intelligent agricultural machinery.
- Develop low-level drivers and communication protocol stacks.

Skill Requirements:

- Proficient in programming languages such as C/C++, and familiar with real-time operating system (RTOS) principles.
- Knowledgeable about hardware driver development (such as IIC, UART, CAN).
- Experience in wireless communication protocol development.
- Familiar with embedded system development tools (such as Keil, IAR).

7.7. Intelligent Agricultural Machinery Algorithm Engineer

Responsibilities:

- Develop algorithms for intelligent agricultural machinery, such as path planning, autonomous driving, and operation monitoring.
- Optimize and deploy algorithms to ensure real-time performance and accuracy.

Skill Requirements:

- Proficient in traditional and deep learning-based algorithm development.
- Familiar with open-source algorithm frameworks (such as ROS, OpenCV).
- Knowledgeable about back-end optimization algorithms (such as Gauss-Newton, Levenberg-Marquardt).
- Familiar with deep learning frameworks (such as TensorFlow, PyTorch).

7.8. Intelligent Agricultural Machinery Application Development Engineer

Responsibilities:

- Design upper-level software for intelligent agricultural machinery, develop ground display systems, and maintain them.
- Optimize user interface design and interaction.

Skill Requirements:

- Proficient in programming languages such as C++, C#, Java, and Python.
- Capable of cross-platform application development (such as Windows, Linux, Android).
- Familiar with common design patterns, and possess good coding standards and documentation skills.

7.9. Intelligent Agricultural Machinery Image Recognition and Radio Communication Engineer

Responsibilities:

- Develop and optimize image recognition algorithms for intelligent agricultural machinery.
- Design and validate wireless communication modules to ensure stable and reliable communication links.
- Integrate visual navigation and obstacle avoidance functions with wireless communication technologies.

Skill Requirements:

- Proficient in computer vision and image processing theories, and skilled in deep learning frameworks (such as TensorFlow, PyTorch).
- Knowledgeable about wireless communication principles and familiar with communication protocols such as 4G/5G, Wi-Fi.

- Strong programming skills in languages such as Python and C++.
- Familiar with ADS simulation tools and capable of using software like Cadence for schematic design and PCB simulation.

7.10. Intelligent Agricultural Machinery Process Engineer

Responsibilities:

- Design and optimize manufacturing processes for intelligent agricultural machinery to ensure production quality and efficiency.
- Develop process technology plans, forming process strategies, and process documentation.
- Track the latest developments in manufacturing processes for intelligent agricultural machinery, propose innovative ideas, and organize technical evaluations.
- Oversee prototype production and process quality control, and solve process-related issues.

Skill Requirements:

- Proficient in mechanical manufacturing processes, such as turning, milling, grinding, and welding.
- Familiar with the functions and working principles of various components of intelligent agricultural machinery, and capable of assembly, debugging, and maintenance.
- Strong technical documentation and report writing skills, and ability to independently undertake production, sub-assembly, and final assembly processes.
- Familiar with quality management systems such as ISO 9001.

7.11. Intelligent Agricultural Machinery Equipment Management Engineer

Responsibilities:

- Maintain, service, and manage production equipment for intelligent agricultural machinery to ensure normal operation.
- Develop equipment management plans, including preventive maintenance, troubleshooting, and repairs.
- Monitor equipment operating conditions, optimize equipment utilization, and reduce equipment failure rates.
- Oversee equipment upgrades and technological improvements to enhance production efficiency.

Skill Requirements:

- Familiar with the principles and operating procedures of production equipment for intelligent agricultural machinery.
- Strong troubleshooting and repair capabilities to quickly resolve equipment issues.
- Proficient in using equipment management software and capable of data analysis.
- Strong teamwork and communication skills.